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alifornia BEEF PRODUCTION

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CALIFORNIA AGRICULTURAL
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EXTENSION SERVICE

MANUAL 2

California
BEEF PRODUCTION

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California Agricultural Experiment Station and Extension Service
The College of Agriculture—University of California

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THE BEEF-CATTLE INDUSTRY

Present Status
Range and Wildlife Problems
Production Costs
Future Possibilities

Even so old and venerable an occupation as beef production may well be reviewed in its position in the general scheme of things. Multitudinous plans are now extant concerning such matters as public-land use, wildlife, recreation, water storage, stream flow, runoff, erosion, and the type of ground cover desired. It is necessary for all this planning to be fitted together in some orderly fashion.

California is an area deficient in the production of beef cattle—and all other types of livestock; furthermore, it does not grow enough feed for the animals that are produced and finished here. Because it is still a great importing state for livestock and feed, its cattlemen should utilize all native resources and find means by which to improve them.

Present Status

Table 1 (Sec. I) shows the number of California livestock and poultry for 1942, together with the production by classes. Table 2 (I) covers the feed requirements for the same year, including pasture and range. Table 3 (I) presents the details of beef production and feed requirements. Since about half of the feed-lot rations are concentrates, at least 90 per cent of the total beef tonnage produced was dependent upon range, pasture, and harvested roughage. For the United States as a whole, only 10 to 15 per cent of the total beef production has been attributed to concentrates.

Stated briefly, the most important problem facing the beef-cattle industry in California is to share with the sheep industry and with wildlife the forage produced on at least 60 per cent of the land area of the state. Few people realize the importance of this natural vegetation in the production of wealth and the improvement of human welfare. Over much of the area the value of the produce per acre is low; but the large total number of acres makes this forage the most valuable crop produced in the state.

Piper and others (1) in a comprehensive report in 1924 on national forage resources, discussed the importance of doing more extensive research on the subject of pastures. Since their observations are equally pertinent today, the following significant statement is quoted from the paper:

> Relegated largely to land too poor or too rough to till, neglected commonly by the farmer, often abused by the grazier, ignored by most investigators, our permanent pastures, both tame and wild, still furnish nearly four-tenths, and our rotation and temporary pastures over one-tenth, of all the feed consumed by domestic animals. Pasture is the key to profitable utilization of

Manual 2, a revision of Circular 131, replaces Extension Circular 115, *Beef Production in California*, by H. R. Guilbert and L. H. Rochford. Some tables and other data from the original circular are used in the manual.

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TABLE 1 (I)

Number of California Livestock and Poultry, and Production by Classes

	Number on farms		Production from farms and feed lots in 1942			
	Jan. 1, 1942, thousands	Jan. 1, 1943, thousands	Meat (live weight), million pounds	Milk (4 per cent fat), million pounds	Eggs, million dozen	Wool, million pounds
Beef cattle and calves	1,526	1,545	475	.....	...	..
Dairy cattle	786*	786*	236	5,133	...	..
Hogs	894	1,019	197	.....	...	..
Sheep	2,977†	2,828†	162	.....	...	24
Chickens	12,494‡	14,034‡	60	.....	159	..
Turkeys	428§	492§	58	.....	...	..

* Milk cows two years old and older.
† Stock animals.
‡ Hens and pullets of laying age.
§ Breeding hens.

Source of data:
California Agricultural Experiment Station. Feed requirements for California livestock and poultry production. 4 p. 1943. (Litho.)

TABLE 2 (I)

Feed Requirements for California Livestock and Poultry in 1942

	Barley (or equivalent), thousand tons	Protein concentrate (40 per cent equivalent), thousand tons	Legume hay, thousand tons	Nonlegume hay, thousand tons	Silage or soilage, thousand tons	Pasture and range	
						Irrigated, thousand acres	Nonirrigated, thousand acres
Beef cattle and calves	176	45	168	391	...	150	40,000
Dairy cattle	177	44	2,623	816	432	224	1,050
Hogs	352	46	21	.....	...	23	......
Sheep	20	10	121	78	...	120	18,000
Chickens	473	146	27	.....	74	...	......
Turkeys	115	25	10	.....	36	...	......
Totals	1,313	316	2,970	1,285	542	517	59,050

Source of data:
California Agricultural Experiment Station. Feed requirements for California livestock and poultry production. 4 p. 1943. (Litho.)

TABLE 3 (I)

California Beef Production and Feed Requirements, 1942

Type of production	Production of live weight		Feed requirements				Pasture and range	
	Amount, million pounds	Per cent of total	Barley or equivalent, thousand tons	Protein concentrates, thousand tons	Legume hay, thousand tons	Nonlegume hay, thousand tons	Irrigated, thousand acres	Nonirrigated, thousand acres
Range and field cleanup	342	72	8	30	111	258	...	40,000
Irrigated pastures	60	13	...	...	...	...	150	......
Feed lots	73	15	168	15	57	133	...	......
Total	475	100	176	45	168	391	150	40,000

Source of data:
Guilbert, H. R., L. W. Fluharty, and V. M. Shepard. California beef-production data. California Agr. Exp. Sta. leaflet. 5 p. 1943. (Litho.)

millions of acres of semi-waste land now lying idle or unproductive. "Better pastures" should be made the keynote in the promotion of American agricultural progress.

From the range breeding grounds in this and in other states come the feeder cattle that go to feed lots and utilize the products of the cultivated lands and the by-products of industry and agriculture. The latter depend upon the return from these by-products for their financial stability, just as the livestock industry depends on this feed supply to finish the livestock. Thus the advantage is mutual; development and utilization of by-products over recent years have belied the old-time statement that California is a poor place in which to eat beef.

At present the livestock industry is handicapped by the limitation of its use of the range. Involved are several conditions, some of which are peculiar to California. Over 40 per cent of the land area of the state is publicly owned. This figure includes such lands as public domain, forest reserves, national parks and monuments, Indian allotments, school sections, and tax-delinquent lands. In addition, there is a large holding of railroad lands; for instance, several million acres belong to the Southern Pacific Railroad. Many of these areas outside the forest reserves are in checkerboard ownership, mainly because every alternate section was allotted to the railroads along their rights of way many years ago. This arrangement prevents the efficient use of such land for grazing.

The Taylor Grazing Act, administered by the Department of the Interior, was designed to bring the feed resources of the 175,000,000 acres of public domain in the United States under some measure of control. In California, with approximately 16,000,000 acres of public domain, two grazing districts have been established (no. 1 in Mono and Inyo counties, no. 2 in Modoc and Lassen counties). Since these districts comprise less than 25 per cent of the public domain in the state, some 12,000,000 scattered acres are without control.

The Forest Reserves, established in 1909, long antedated the Taylor Grazing Act. For years after controlled grazing under the paid-permit plan was provided in these extensive areas, which cover 19,000,000 acres of the state, grazing resources were expected to be gradually increased. But after thirty-five years, this expectation still has not been realized. Figure 1 (Sec. I) shows the trend in numbers of paid permits for domestic livestock grazed on national forests in California from 1910 to 1946, and also the trend in numbers of animals over the same period. There has been a marked decline in both. The complete picture is even more serious because, in too many areas, the reduced number of livestock come out of the mountains in poor condition and must go to the feed lot, not direct to slaughter as in former years.

In short, the future beef-cattle situation in California is primarily involved with feed supply, in which natural vegetation on ranges and pastures is the most important item.

The use of these lands, whether in public or private ownership, depends on the accumulation of more and more factual data. With facts, procedures can be inaugurated to make way for increasing numbers of animals and to assure better handling of those that already exist. In this way the consumer can be supplied with livestock products so that his diet will better meet his physiological needs. Efficient production will bring costs in line with purchasing power, without too great a strain on other important living costs incidental to a better life for the entire population.

Information on the physical resources that affect livestock production in California, including climatic data, land use, characteristics of the different production areas, and statistics on the movements of feeder and slaughter cattle from outside the state and inside, can be found in the

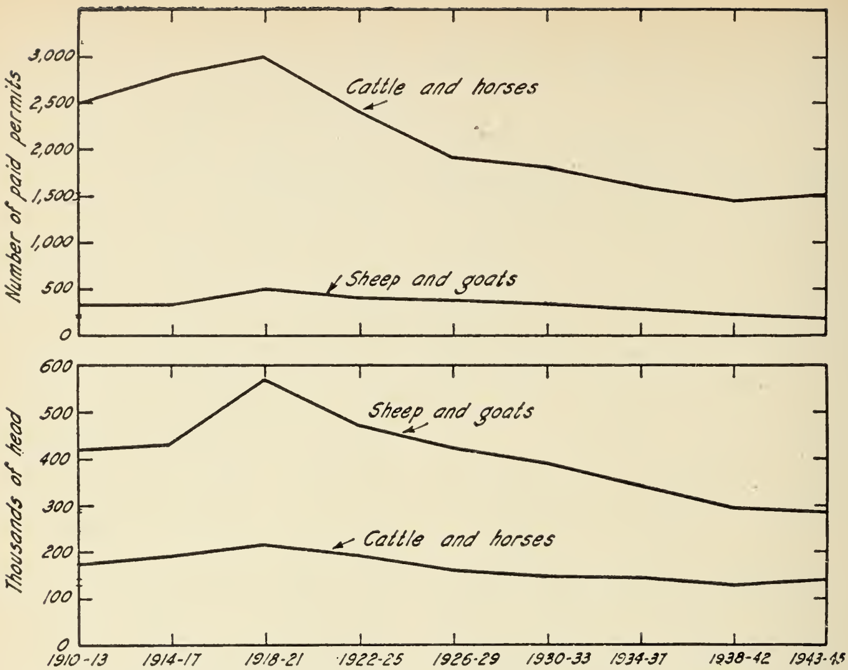

Fig. 1 (I). *Upper panel:* Trend in numbers of paid permits for domestic livestock grazed on national forests of California, from 1910 to 1945, four-year averages. *Lower panel:* Trend in numbers of domestic livestock grazed under paid permit on national forests. Data from United States Forest Service, California Region. (From Ext. Cir. 115.)

publication of Swedlund and Scott (2) and its supplements. Arthur Shultis (3) also gives information on such agricultural data as regions, climate, and types of agricultural enterprises.

Range and Wildlife Problems

Since the turn of the century, much progress has been made toward a better understanding of soil and plant relations, especially under irrigation practices. There is now a need for more study of plant and animal relations, particularly on the uncultivated lands. Forage stand on the range and its composition in relation to livestock and wildlife must be considered. In this connection, Shelford (4) attacked the fundamental concepts of certain plant ecologists who apparently consider and name vegetation apart from animals. These ecologists have desired to learn the ultimate climax of vegetation with the wild animals, or their equivalent in domestic animals, excluded or reduced to the early or original numbers. Shelford restated the unity of the plant-animal community and suggested principles that make such a concept tenable. He expresses his views as follows:

> That a much broader and more flexible view of controlling factors is tenable than the one which holds that the animals are merely an environmental factor acting upon plants. That food relations, especially of abundant and influent animals, are usually flexible and rarely if ever obligate; and that observation of apparently restricted food relations made in one locality may not hold good under other conditions. That the climaxes of nature (bioecological climax) include that vegetation which occurs with the pristine numbers and kinds of animals present.

Regarding bioecological climaxes, Shelford claimed that if bison held some of the mixed prairie to the short-grass stage, then short grass was the bioecological climax, even though the climax with bison excluded would have been quite different.

California has not greatly increased its number of beef cattle and sheep in the last forty years. On the other hand, through administrative policies preventing the use of fire, great changes in the ground cover of vegetation have occurred over a large acreage. Brush cover, chamise, and chaparral of low forage value have spread over land formerly producing good ground feed. These large, ungrazable, brush-covered areas have created a vicious circle in the scheme of grazing. Since the same number of animals is grazing less and less acreage, and since wildlife competition continues, the result is lower available feed, poorer condition of livestock, and greater opportunity for so-called overgrazing. The use of fire in brush clearing has been extremely controversial. Indiscriminate burning is as ill-advised as attempting to prevent all fires. Coöperation between state and federal forestry agents, the university and county livestock groups on well-planned, selective, controlled burning of brushland, followed by constructive management practice and reseeding where necessary, is now making progress in enhancing feed supply and in contributing essential knowledge upon which future practice may be based.

In addition to burning, the practice of bulldozing and other mechanical methods of brush clearing, followed by planting to grain crops or reseeding with forage plants, is being followed more extensively on the better sites and soils. Most of the burning and clearing for improvement has been done at the dense brush stage. Evidence is accumulating that control at the more open stage even with a year's sacrifice of the grass cover required to carry the fire may be the more practical and profitable procedure, involving large areas. With some brush types, clearing the remaining seed plants by hand or by other means may prevent recurrence indefinitely (5, 6).

Chamise, in particular, is so dense over large acreages that grazing animals cannot penetrate the stand. It is too woody for browse feed and constitutes a serious fire hazard. On the other hand, the tender sprouting shoots which come up after a fire has burned it off are fairly palatable and nutritious, and are utilized along with the ground feed which comes up in quantity after the removal of brush-cover competition. Work done by Veihmeyer and Johnston (7) in Shasta and Tehama counties has demonstrated the fact that, along with an increase in feed, water is conserved in the soil. In the experiments, denudation by burning did not impair infiltration capacity; the soil in burned plots became wet throughout its full depth as soon as that in adjoining unburned plots. The more shallow-rooted ground cover following the burn did not transpire so much water as did the deeper-rooted chamise; in every instance, the total water loss at the end of the dry season for the full depth of soil was less in the burned than in the unburned plots.

During the dry season, restoration of spring and stream flow, following removal of brush and trees, frequently occurs. This is often vital in maintaining water supply for livestock in such areas.

The much-abused term "overgrazing" has been widely used by writers discussing the problems of uncultivated land. There are marked differences in the type of vegetative cover on range lands; over much of California the ground feed consists predominantly of annual plants. This situation is generally thought to have resulted from excessive use of perennials and especially from prolonged summer grazing, which has caused these plants to decline and to be replaced by annuals. Some annuals are miscalled weeds, despite their high nutritive value to animals.

It is recognized that at intervals most perennials must be allowed to reach the flowering stage in order to maintain vigor by replenishing the store of nutrients in their roots. Enough seed must be produced for replacement or increase. Just as alfalfa has a shorter life and produces

less yield when continuously cut before bloom, so will perennial grasses lose their vitality and productivity under continuous close cropping. Annuals, on the other hand, depend solely on seed and the growth of new plants each year. The annuals common to California are remarkably adaptable; their abundant seed insures future crops even under the adverse conditions induced by lack of moisture, a short growing season, or very close grazing. Successful seed production is accomplished by many species, when height growth is limited by grazing or drought to 2 or 3 inches, even though a height of 12 inches or more would be normal under favorable circumstances. As further insurance of species survival, not all the seeds germinate at once; in such species as bur clover, seeds may remain viable in the ground for several years.

Domestic animals are obliged to compete with wildlife for the natural vegetation. The term "wildlife," in connection with range lands, properly refers not only to game animals, but to all undomesticated vertebrates and even invertebrates. The importance of grasshopper and locust damage is widely recognized.

Since game animals constitute a crop, they must be managed so that their numbers and the available feed supplies remain in proper balance, especially where predators are under reasonably strict control. The highly important rodent and related species must be looked upon as game (cottontail rabbits and gray squirrels), and also as pests and reservoirs of human infections, particularly sylvatic plague and tularemia. Collectively, wildlife over much of the range area has more effect on the vegetative cover than have domestic animals.

In 1944, Storer, Evans, and Palmer (8) reported a great many data on some rodent populations in the Sierra Nevada regions of California. "Rodents," they state, "constitute one of the major dynamic forces of nature; they are second only to the insects and well above the hoofed animals, wild and domestic, as primary converters of vegetation." At a field station near Bass Lake, Madera County, these investigators showed an active population of 60 rodents per acre in summer—mice, chipmunks, ground and gray squirrels, gophers, and chickarees. It was calculated that 23.5 pounds of rodents had a food consumption of 1.6 to 2.6 pounds of dry matter daily. They estimated that a 750-pound steer daily needs about 14 pounds of dry matter. Sixty rodents on 1 acre, therefore, require 12 to 18 per cent as much as a beef animal, and those on 5½ to 8½ acres have a food demand equivalent to that of one average steer.

Just south of Bass Lake at O'Neals is the San Joaquin Experimental Range of the United States Forest Service. Although some of the rodent species found at Bass Lake are not a factor on this range, they are replaced there by cottontail and jack rabbits, and kangaroo rats.

Horn and Fitch (9) from their studies at this location, present data of a similar kind. They indicate that the forage consumed and destroyed by pocket gophers is largely compensated for by the increased production which their cultivating activities in the soil accomplish. Ground squirrels (6 on ½ acre) and kangaroo rats (8 on ¼ acre) were shown to be detrimental; without doubt, they took 15 per cent or more of the forage on the plots where they were maintained. The stocking of the enclosures was about equal to the maximum population densities known to exist on the range at the start of the experiment.

The Division of Animal Husbandry of the College of Agriculture, in coöperation with the Forest Service, has been studying different intensities of grazing on the San Joaquin Experimental Range over a period of twelve years. Animals were placed in fenced areas at the approximate rate of one to 10 acres, one to 15 acres, and one to 20 acres, respectively.

All these data tend to show the importance of rodents as an uncontrolled variable in grazing-intensity studies with livestock. With cattle stocked at the rate of one to 10 acres, the rodents may eat and destroy forage sufficient to feed more than one steer; at the rate of one to 15 acres, twice as much; and at the rate of one to 20 acres, about three times as much.

The conditions for which rodents may largely be responsible should not be charged against livestock. Furthermore, high utilization of the vegetative cover is not so serious from the plant-reproduction standpoint on ranges composed of annual plants; and systematic rodent control soon pays dividends.

The deer population in California is very large—roughly, about 1,000,000 head. In many places it is too large for the feed supply, and losses from disease and starvation occur every year. Fischer, Davis, Iverson, and Cronemiller (10) of the United States Forest Service have studied the winter range of the interstate deer herd in the Modoc National Forest.

In this forest the estimated deer population has increased from 6,700 in 1923 to 46,000 in 1943. The livestock has been continuously reduced from 35,404 cattle and 76,539 sheep in 1923, to 23,907 cattle and 46,308 sheep in 1943. Deer and livestock are not alike in their grazing habits and plant preferences. The strain removed from the plant cover by reducing permits for cattle 32.0 per cent and permits for sheep 39.5 per cent has been taken up by the increased deer population. Plant species favored by deer have continued to decline, while those selected by livestock are increasing. The authors recommend that 10,000 does be killed in this area. Unless this problem is handled wisely, nature will step in with increase in predators, disease, and starvation; natural resources will certainly be wasted. The means by which these problems are handled may well be considered an index of the enlightenment of the people.

Not many years ago cattle were allowed to live or die on the natural vegetation of the range. Today, the supplementing of range feed is essential and highly profitable. To many it may appear fantastic to fertilize range lands; but the future may prove fertilization to be a valuable and economical means of producing a greater amount of nutritious range feed.

Range lands differ greatly in productivity and in quality of feed. Moisture is the greatest limiting factor in all the low-altitude ranges, whereas temperature and length of growing season are important at the high altitudes. In most of the rolling foothills, cattle prefer different areas at different seasons, south slopes over north slopes, bald over open wooded areas, open areas over those under tree cover, and swales over knolls. Type, palatability, and nutritive value of plant cover are involved in these preferences. In some areas cattle spend most of their time grazing swales, where the feed stays green longer. Production in such locations has been increased experimentally five- to ten-fold by the use of fertilizers.

The establishment of superior plant species through reseeding and management offers great promise. As this knowledge unfolds, the effects of management of grazing practices on the plant cover may become as important to beef-production enterprises as the management of the cattle. Jones and Love (11) give a detailed report on the species of forage plants recommended for reseeding in different areas of the state; this circular also gives information on the management of brush fields and grazing management practices to increase the quality and quantity of forage production.

Production Costs

Since 1935 the Agricultural Extension Service of the University of California has coöperated with 87 cattle producers in 14 counties to study and analyze beef-production costs. Three distinct areas are involved in these studies: the northeast

mountain area, the south coast, and the San Joaquin Valley. On most of these ranches, sales of beef cattle represent the major source of revenue, with the cattle being used principally to market the range and pasture feeds and the harvested roughages. All the ranches in the studies maintain breeding herds. A few of the operators purchase some stockers and feeders. On the average, about 280 breeding cows and a total of about 730 animal units per ranch are represented in these studies. The progress of the project warrants discussion of the following important factors in beef-production costs.

Capitalization. Based upon the prewar period, when the average price of all cattle was about $8.00 per hundredweight, and where the beef enterprise must be charged with all the capital investment in a ranch unit, net returns have not justified a land and facility investment much in excess of $125 per animal unit, where the operator expects net earnings of 5 per cent. In the studies the average investment in land and facilities per animal unit is shown to be $161.66. The extremes range from $90.76 to $187.46. Where an interest rate of 5 per cent was figured on capital invested in range and pasture land, cattle, and facilities, the charge against invested capital accounted for 41.9 per cent of the sale value of all beef.

The danger of overcapitalization of the beef enterprise appears to be greater on specialty beef-cattle ranches than on those where beef-cattle production is merely a part of the general farming program.

Percentage Calf Crop. The records show a direct correlation between percentage calf crop and net income on these ranches where the prevailing practice is to maintain breeding herds. Under prewar price and cost conditions, and with practices then employed, an average of 70 per cent calf crop appears necessary on these ranches to prevent financial loss. This percentage is based on the number of breeding cows two years old and over in the herd. The average percentage calf crop shown in the study is 71.6 per cent, with extremes from 50.6 to 95.2 per cent. The younger the animals are when sold, the greater is the necessity of obtaining a high percentage calf crop.

Beef per Animal Unit. In the study there is a direct relation between annual production of beef per animal unit and the net returns. For the ranches studied, this production has averaged 291 pounds, with extremes from 116 to 482 pounds. The amount is closely associated with percentage of calf crop and age of marketing. About 285 pounds of beef per animal unit, under the prevailing price and cost conditions, were required for these ranches to pay total operating expenses of the cattle enterprise.

Age at Marketing. Where these operators breed and raise their cattle, the studies point out, the greatest net income per animal unit is obtained when market animals are sold between the weaning and the two-year-old stages. An analysis of the records indicates that the optimum point for selling within these age limits depends mainly on percentage of calf crop, weight for age, and quality of cattle.

General Management. The studies emphasize the need for analyzing each ranch unit separately, in order to find the best methods for applying fundamental principles of management. They also show that certain production and marketing practices efficient for one ranch may not be applicable to another.

As a group, the ranch operators showing greatest net returns above all costs, invested more time and money in systematic and careful breeding, feeding, and culling practices than did the low-income group.

Shultis (3) makes the following statement:

> Cattle . . . ranches vary widely, by location and kind, in the size of the herd, and the acreage required for an adequate family farm. Usually 100 breeding cows are considered necessary, with sufficient owned or rented range land, and sometimes with enough cropland to produce the

required hay for supplementing the range. Where all land is owned, as in the Coast Range, 500 to 5,000 acres are required for a herd of this size, with an investment probably around $20,000 for the range alone. Even in the mountain region, where grazing rights on public lands are available to ranchers, the total investment for a stock ranch is rather high, since hay land and private range are also required. The land, buildings, and livestock would mean a minimum investment of $25,000 to $30,000 for a cattle business of 100 cows, with the usual bulls and young stock. In fact, cattle ranches are usually larger than this minimum and are rather strongly held by owners of substantial means, so that there is little opportunity for the newcomer with limited capital.

Future Possibilities

It is possible to foresee, in the field of beef-cattle breeding, an era of greatly expanded potentialities, which depend largely upon the vision and progressiveness of breeders. Knowledge has been accumulated to a point where the objectives may now be more clearly defined. Progress has been made on the means by which progeny performance can be systematically recorded, and bulls and females proved for their ability to transmit desired characters to their offspring. Information on the mechanisms of inheritance and on breeding methods has increased. Above all, the techniques of artificial insemination have been sufficiently perfected so that 100 inseminations can be secured from a single service; dilutions of semen adequate for 40 to 80 inseminations are common practice. The rate of genetic improvement is limited largely by the degree of selection possible. Artificial insemination greatly extends the selection potential for sires. Already one beef bull has sired well over three thousand calves. By this means, an outstanding proved sire very easily could produce a thousand bulls for normal use in commercial herds and thus become the grandfather of a hundred thousand calves!

The action of hormones is gradually being elucidated. Hormonal and other physiological variations are involved in genetic selection for type and special production functions. Development of this knowledge should more clearly define the issues for breeders and geneticists alike, and should show what combinations of functions are compatible and genetically attainable and what combinations are antagonistic. General evidence, for example, indicates some degree of antagonism between ease of fattening and milk production. It is known that excessive fattening may be associated with hypothyroidism and that extra thyroxine will stimulate added production of milk even in dairy cattle. Apparently, on the other hand, good beef conformation obtained by selection for shorter leg bones and thick muscles without excessive fattening tendency is compatible with high milk production. This is exemplified to an unusual degree by the comparatively new Dutch dual-purpose-type Friesian cattle.

Physiologists and nutritionists have progressed toward a clearer understanding of rumen function, activity, the interrelations among the microörganisms in the rumen and between these and the host. This information is involved with the causes and prevention of bloat, and offers a logical explanation of long-established practices, such as gradual changing of rations, of indigestion and toxemia from sudden feed changes. Possibly it may also be concerned with metabolic disturbances or diseases, such as grass tetany, acetonemia, and the etiology of the "acorn calf." Microörganisms of the rumen are important not only in digesting fiber, but also in synthesizing numerous vitamins, proteins from nonproteins—one type utilizing the by-products of another, preventing accumulation of toxic materials, all of which is essential to the well-being of the cow herself.

These strides indicate that the problem of supplemental feeding involves not only the needs of the cow, but also promotion of most favorable conditions for her partnership with the microörganisms in her rumen, or paunch.

Great progress is being made in controlling some of the insect pests that take such a tremendous toll in the livestock industry. The remarkable effectiveness of DDT, for example, has brought about intensive selective pressure on certain insects, and survivors have produced new populations of resistant types. The problem of thus producing strains for which there are no effective control measures is now being appreciated.

Many opportunities exist for increasing the efficiency of production—not only by improving the environment to suit the animals, but also through breeding animals that are adapted to the existing environment.

Improvement of environment implies knowledge of the physiological requirements of cattle for growth, fattening, reproduction, and lactation. It involves the practical application of this knowledge to secure adequate nutrition; to control parasites and diseases; to regulate temperature through shelter, shade, or other means; to provide an ample supply of water; and to improve other management practices that promote the wellbeing of the animals and their efficiency of production.

What is considered relatively new today may be commonplace tomorrow. Possibilities lie ahead, ready to be exploited, if the cattlemen will but study the available data on their business more critically, more extensively, and more intensively than ever before. To facilitate such a study, this manual summarizes the information—obtained by experiment and by practice—that is considered most practical and helpful in improving the efficiency of beef-cattle production in California.

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J. Earl Coke, Director, California Agricultural Extension Service.

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PHYSIOLOGICAL PROCESSES AND CATTLE BREEDING

Physiological Processes
- Reproduction
- Basis for Inheritance
- Rumination
- Rumen Fermentation
- Water Utilization

Cattle Breeding
- Market Factors
- Production Factors
- Records of Performance
- Selective Breeding
- Crossbreeding

Physiological Processes

Reproduction

According to many studies and practical observations, a high reproduction rate is important to the financial stability of a beef-cattle enterprise. The rate varies significantly with environmental conditions, especially feed supply. For example, low calf crops follow periods of drought and poor range feed.

Lactation constitutes a greater drain on the breeding cow than gestation. This is the basis for the much-discussed plan of breeding cows to calve at two years of age and vealing the calves early, as presented under "Production of Feeder Cattle," Section IV. The establishment and maintenance of normal rhythm of estrus cycles (heat periods) in the open animal is a more delicate index of a normally functioning physiology of all body processes than is growth curve or weight gain. Breeding cows commonly lose weight during the dry season, which usually coincides with the latter part of gestation. With calving, a further weight loss occurs, upward of 100 pounds, followed by lactation on green feed. In spite of good feed, the drain of lactation will often prevent gains or will even result in losses. Thus the cow may pass through the breeding season without showing heat periods and so miss having a calf the following year. To prevent this trouble, one should supply the breeding cow with feed that will enable her to return to her normal weight at calving time each year. Means for accomplishing this result are given under "Percentage Calf Crop" in Section IV, "Production of Feeder Cattle." Supplying 1 bull for every 15 breeding females will not help the situation when the need is for supplemental feed to bring the breeding cows into heat. Given proper feed, 25 or 30 cows can be served by a single bull.

Estrus, or heat, is the external manifestation that the genital tract is functioning normally. Involved are the development of a Graafian follicle containing the ovum or egg in the ovary, ovulation, and preparation of the lining mucosa of the uterus for the implantation of the fertilized egg. These processes are under hormone control.

Gonadotropin, a hormone secreted

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from the anterior part of the pituitary, a small ductless gland at the base of the brain, stimulates the growth of the Graafian follicles in the ovary. One follicle will mature at each heat period (two follicles in the case of twins), rupture, and extrude the ovum and follicular fluid. The cavity thus created is filled by the formation of the corpus luteum, or yellow body of the ovary. Under the stimulation of growth, the follicle produces the female sex hormone, estrogen, which is found in the follicular fluid. This hormone stimulates the secretion of mucus in the vagina, initiates contractions and growth changes in the uterus, and brings on the manifestations of estrus. The corpus luteum secretes another hormone, progesterone, which stops uterine contractions and continues to prepare the lining of the uterus for implantation of the fertilized ovum and the maintenance of pregnancy.

The same pituitary hormone, gonadotropin, activates sperm production in the male and stimulates the testes to produce from special cells the male sex hormone testosterone. This in turn, by stimulating the prostate gland and seminal vesicles (the accessory male glands), produces sexual desire.

The sex hormones secreted by the testes and the ovary also control the development of secondary sexual characteristics—masculinity in bulls, femininity in females. Spaying a heifer changes her body conformation somewhat and results in coarser appearance of the head. The alteration in appearance of a steer, compared with the well-developed crest, more massive head, horns, and shoulders, and deep voice of a bull, is well known. Variation in sex-hormone secretion is responsible for difference in development of these characteristics in individuals. Stockmen have empirically long associated the combination of characteristics recognized as femininity with good breeding cows that are good mothers; strongly developed masculine appearance with good breeding bulls. Normal sex-hormone secretion is the scientific explanation of these practical observations.

Evidence from an extensive literature on the relation of nutrition to reproduction has been reviewed (1). This indicated that low food intake or any deficiency (as of protein or phosphorus) that affects appetite may act through the pituitary gland to cause cessation or irregularity of heat periods in the female and to limit sexual desire and activity in the male. Protein deficiency seems to have a direct effect on the pituitary, independent of appetite or food intake.

Under these conditions of nutritional deficiency all body cells, including the pituitary and sex glands, are affected. Reduction of hormone secretion from the pituitary under such circumstances has been demonstrated. Thus the direct effect of inanition, with lessening of hormone stimulation, is "doubled up" on the ovaries or testes and could explain the observed cessation of estrus and sexual desire. Injection of the gonad-stimulating hormone into animals suffering nutritional privation has restored estrus and ovulation in the female and sexual desire in the male. The generally recognized fact that reproductive functions are more sensitive to undernutrition than most other physiological processes may thus be explained.

The mechanism indicated, indeed, may be a wise provision of nature to prevent the onset of reproduction under conditions unfavorable to survival of both mother and offspring, and to assist the adult animal to live through the critical period.

Vitamin-A deficiency, on the other hand, does not affect the recurrence of heat until the advanced stages, when appetite declines and the animal's general condition is impaired. Breeding has been observed with experimental animals in the convulsive stages, but pregnancy was not established. Deficiency to the night-blindness stage during pregnancy causes changes and necrosis of the placenta. Op-

portunity for infection is increased; the fetus may be killed and aborted, or born too weak to live. Vitamin-A deficiency in the male causes sterility through degenerative changes in the sperm-producing cells of the testes, but does not affect sexual desire until advanced stages. The testicular damage is slowly repaired if sufficient vitamin A is again supplied.

Insufficient iodine causes reproductive failure through development of the deficiency syndrome in the fetus that is still in the uterus; but the mother shows no clinical signs of the trouble.

When the delicate reproductive phenomena are not occurring, the cow misses rebreeding, gains weight as lactation ends, and is more fleshy than the animals that are again lactating. If bulls are present she may become pregnant in the late summer or fall and calve late the following year or early the second year after having her last calf, or be sold for slaughter in the winter because she is in good flesh or thought to be barren. This accounts for the large number of fetuses on the killing floors in the winter season. When pregnancy has gone beyond about 5 months of the gestation period, it affects dressing percentage.

Physiological Basis for Inheritance

The body cells of cattle contain 30 pairs of bundles of hereditary determiners called chromosomes—a total of 60. In the formation of each ovum, or egg, and each sperm, one or the other of each pair is included, so that each germ cell has 30 chromosomes. These carry the determiners of the hereditary qualities of the individual. When the egg and sperm unite, the resulting new individual has 60 chromosomes, one half coming from each of its parents. In turn the new individual will contribute 30 chromosomes to its offspring, passing along one or the other of the members of each pair that it received from its parents. This is the "halving and sampling" process of inheritance; the inclusion in the germ cell of one or the other member of any pair is due to chance.

With all possible combinations of these 30 pairs, any cow or bull can transmit over 1 billion different samples of its own inheritance; and the combination from both parents makes possible 1 billion times 1 billion genetically different offspring. It is not strange, then, that no two individuals (except identical twins from a single egg split after fertilization) are exactly alike. This variation gives one an opportunity to select for desired characteristics. Selection and systems of breeding, such as inbreeding and line breeding, are means of obtaining sires and dams whose chromosomes contain similar hereditary determiners, so that the amount of variation is reduced.

Some applications of these basic concepts, along with important factors to consider in beef-type selection, are discussed under "Cattle Breeding."

Rumination

Strictly herbivorous animals, such as cattle, sheep, deer, and horses have special anatomical arrangements of the gastrointestinal tract to care for large ingestion of roughage. The first three species named have a four-stomach arrangement; and the horse has a large caecum, or blind gut, whose counterpart in man is the small, rudimentary vermiform appendix.

The four-stomach species are classed as ruminants because the first stomach, or rumen, can return boluses of ingesta to the mouth by reverse peristalsis of the esophagus. The bolus is then remasticated and again swallowed, the entire process being known as rumination, or chewing the cud. Eructation or belching, a closely related phenomenon, is used in eliminating the gases that form through fermentation. When expulsion of these gases is interfered with, the immediate result is bloating, which may even cause death.

Rumination and eructation are involuntary or reflex acts, the nervous stimulus for which is the scratching of coarse roughage on the mucosa of the anterior portion of the rumen. This stimulation was first demonstrated by workers at the South Dakota Station. Through a fistula the experimenters passed an arm into the rumen and, by scratching the mucous membrane, started the eructation. Cole and his coworkers (2) of the Division of Animal Husbandry, University of California, have demonstrated the cause of bloat to be a lack of sufficient coarse roughage. Bloat was produced experimentally by feeding cows on soft, lush upper stems and leaves of alfalfa and prevented by giving them coarse hay before turning them out to pasture. Sudangrass likewise inhibited bloat, because the edges of the leaf are rough and maintain the constant stimulus for eructation. In experimental dairy animals fed no roughage from calfhood, but supplied with concentrates only, Mead of the California Station demonstrated a failure of the rumen to develop; no rumination took place, and too heavy a feeding at any one time always resulted in some degree of bloat. In view of this knowledge, the stockman should recognize that when bloat occurs on pastures or ranges, the feed is too lush and tender. On such range feed and irrigated pastures, the animals need access to coarse hay or straw for the normal functioning of their digestive apparatus. Insufficient roughage tends to reduce appetite and gain, even if acute bloat is not produced. Recommended minimum roughage allowance is discussed under "Fattening Cattle and the Dressed Product," Section V.

Rumen Fermentation

The fermentation constantly going on in the rumen results from the growth and activity of microörganisms. Nutritionists have made important progress in understanding some of the interrelationships and functions, but the problems of research are extremely complicated and knowledge is by no means complete. Digestion in the rumen is accomplished by enzyme systems produced by the microorganisms. The principal products of carbohydrate digestion in ruminants are volatile fatty acids such as acetic; in nonruminants the main end product is sugar (glucose).

Bacteria are primarily concerned with cellulose digestion, but they also act on starches and sugar, producing lower fatty acids, carbon dioxide, and methane. These fermentation gases must escape through belching, or bloat occurs. Infusoria, with the help of bacteria, break down carbohydrates and proteins, and synthesize from amino acids animal proteins of high value. The microörganisms also synthesize vitamins and proteins from nonprotein nitrogen, such as urea. This reworking of the proteins and nonprotein nitrogen of feeds into bacterial and infusorial protein, which becomes available to the host lower in its digestive tract, explains why biological value of feed proteins is not so important in ruminants.

The identity of the different types of organisms making up the rumen flora and fauna is not well established, but there is strong evidence that they are interdependent in function and that the proportions of different types vary with the feed supply. Inoculation apparently is passed more or less directly from one animal to another, as the organisms do not long survive outside the anaerobic conditions of the rumen. It appears that when the composition of the ration is altered, some time may be required for the active flora to adapt to the new feed. The dying out of various types of microörganisms has been demonstrated experimentally in animals fed very deficient rations. In some cases, the animals failed to respond on a good diet until they had received inoculation of rumen contents from a normal animal. Changing from a poor ration to a rich diet may lead to toxic

effects because the microörganisms which utilize decomposition products of proteins, for example, may not be present in sufficient numbers.

Fineness of grinding or other factors, such as very lush pasture, speed the passage of feed through the rumen, decrease cellulose digestion, and increase the amount of carbohydrate digested to glucose by intestinal enzymes. Decline in butterfat percentage of milk has been observed under these conditions.

Slowness in getting animals on feed after long fasting is probably due to complete dying out of rumen microörganisms and slowness of reinoculation. Thus, science has now shown justification, in some cases, of the old practice of transferring the cud of a healthy cow to a sick one, although the efficacy of the dish rag in lieu of the cud has not been verified! These advances in knowledge, which explain the necessity for gradual change in ration when large differences in composition are involved, offer logical reasons for many difficulties encountered in practice.

McElroy and Goss of the California Station and others have demonstrated that the rumen contents of the cow are an excellent source of thiamin, riboflavin, pantothenic acid, nicotinic acid, pyridoxine, biotin, and fat-soluble vitamin K. Thus, under normal feeding practice, cattle do not need a source of the vitamin-B complex in their diet; they obtain it from the microörganisms that manufacture the complex in their own bodies. On the other hand, the foregoing evidence indicates that, under poor, dry range conditions, the rumen contents are lacking in necessary nutrients for the normal processes of fermentation. As a consequence, the welfare of the animal may be impaired.

Water Utilization and Heat Regulation

Water supply and body-heat regulation in husbandry deserve much more attention than they usually receive. Particularly is this true in semiarid parts of the world, where either quantity or quality of water and high temperatures frequently limit stock-raising activities. In many parts of California inadequate water supply is a yearly problem, which may necessitate the removal of cattle from grazing areas before the feed supplies are exhausted. Waters unfit for man to drink must sometimes be given to livestock. The excess of such solids as nitrates, magnesium, sulfates, and sulfites may result in so-called alkali poisoning, with diarrhea, general weakness, loss of appetite, and even sudden death. The upper limit of tolerance for cattle, according to the Oklahoma Agricultural Experiment Station, is 1.5 per cent total dissolved salts. When obliged to walk far to a source of supply (the distance should not exceed 2½ miles) the cattle can drink enough water at one time to suffice for 24 hours. Traveling long distances to water is hardest on cows nursing calves and may be a primary cause of weight loss. Water is essential to the functioning of all body cells; to the transport of nutrients in digestion, absorption, and blood circulation; and to the elimination of waste products. It is a primary factor in the regulation of body temperature and is necessary in the mechanics of rumination. Without sufficient water, rumination ceases, all digestive processes are impaired, and feed consumption decreases or stops.

On many cattle ranges, much can profitably be done to increase water supply and improve distribution in relation to the range feed. This is an important consideration in efficient range use and management. The amount of water, as such, consumed by livestock depends on the water content of the feed, temperature, shade, frequency of access to the supply, and lactation or nonlactation. Water in the feed in arid areas varies from 80 per cent or better in green feed to as low as 10 per cent in the bleached dry feed in the dry season. Thus, with great demand

for water intake in hot weather and low water content of dry feed, an average daily consumption of 10 to 15 gallons per head should be provided. Lactating animals may consume more, and young animals less. The Minnesota Station has presented data showing that milking cows require 3 pounds of water per pound of milk produced. There is evidence, however, that after general requirements are filled, no more water should be needed for lactation than the actual volume of water contained in the milk.

Water Utilization. Water is lost from the body through urine and feces, evaporation from the skin and lungs, and milk production. For a fully grown animal, intake should equal outgo. On the other hand, a growing animal will require water to form a part of its new body tissues. In general, the water content of feces is about 80 per cent. When dry range feeds are deficient, and especially when feed is low in total soluble mineral, the feces are dry, tend to pile up, and contain less than 80 per cent moisture; this condition indicates that the animals are not doing well. The condition of feces in feed lot, as well as on range, is a valuable index. The total weight of the feces varies with diet and water content.

According to Leitch and Thomson (3) on the average the water in the feces of steers and dry cows appears to approximate four times the dry matter; in lactating cows, over five times.

Urine is the means of eliminating waste products from the system, particularly the end products of nitrogen metabolism in the form of urea. It also stabilizes water in the body when sudden changes in temperature occur, with greater or less loss from the skin or lungs. Sudden increase in quantity of urine from exposure to cold results in a fluid of less concentration. In general, 5,000 to 7,000 milliliters—roughly 5 to 7 quarts of urine—will be voided daily. Excessive urination and correspondingly greater water intake occur when cattle consume beet tops, which are high in soluble mineral and possibly in other substances having a diuretic effect.

Heat Regulation. In warm-blooded animals the body temperature is regulated within very narrow limits by delicate adjustment of heat production and dissipation. Heat production occurs from fermentation in the rumen, from combustion of food, and, in animals losing weight on poor feed, from combustion of the body tissues. The animal also absorbs heat from both sun and ground radiation and from the air when the temperature is higher outside the body than inside. Disposal of heat occurs by evaporation of water from the lungs and skin and also by radiation and conduction from the body surface. When the air temperature is low, loss of heat is easier by radiation and conduction. In the summer, when air temperature may exceed body temperature, loss of heat by radiation may be less than the amount absorbed; and then the animal pants with shallow, rapid respirations to dissipate heat by greater evaporation from the lungs. The sweat glands of cattle have less functional development than those of horses or man. At 85° to 95° F, however, evaporation from the skin is three to four times that from respiration, according to Missouri data. Length, color, and texture of hair coat affect heat exchange by radiation and conduction.

Forbes and his co-workers (4), in basal metabolism experiments, have shown marked differences in shorn animals in a calorimeter when increased heat production for maintenance of body temperature occurred at 66° F. The regrowth of hair in the same animal reduced this critical temperature to 56½° or below. Water loss by evaporation from the lungs in the cow is considerable, the upper limits being 10 to 12 quarts in a 24-hour period. Atmospheric humidity apparently plays a minor role in this water evaporation. Regan and Mead with experimental Holstein dairy cows in a psychrometric room at Davis found that a humidity of 90 per

cent of air saturation affected the animals very little compared with temperature. When the latter was maintained at 80° F with humidity at 60 per cent for more than 24 hours, the body temperature rose above normal, with the result that milk flow and feed and water intake decreased. Thus, decline in appetite results at the upper critical temperature (the environmental temperature beyond which the animal cannot prevent body temperature from rising above normal).

These facts emphasize the importance of weather as an environmental factor. Feed capacity and utilization are the important criteria in animal production; but under rigorous climatic conditions in warm countries and seasons, ability to dissipate heat must be considered.

The low milk yields of European dairy breeds in the tropics have been attributed to loss of energy under high temperatures, when extreme panting to dissipate heat forces the whole body into rhythm with the flank movements. The temperatures were such that all heat dissipation necessarily resulted from water evaporation, since none could result from radiation.

In practical beef production, the difference between a good "doer" and a poor one may often lie in greater ability to dispose of excess heat. English investigators found that the average skin temperature of 8 fattening steers that had gained an average of 19 pounds weekly for the preceding 3 weeks was 20.7° C; for 5 that had averaged 12 pounds per week, 22.2° C.

Native tropical breeds, such as the Brahman and Afrikaner, are physiologically fitted over generations and centuries of adaptation to such environment. They manifest lower pulse and respiration rate than European breeds under identical conditions, and do not seek shade so quickly.

Some of the fundamental differences between temperate-zone and tropical breeds that influence the greater heat tolerance of the latter follow.

1. Relatively greater skin area and thus greater surface for heat radiation in relation to weight.
2. Relatively greater ability to perspire. Data show more water evaporation from the skin, and limited histological studies on skin sections showed greater numbers of sweat glands.
3. A distinctly shorter hair coat, which, regardless of color, is generally found on pigmented skin. Many types have light hair color that reflects a higher proportion of sun radiation. South African clipping tests revealed 303 grams of hair in the summer coat of a 600-pound Shorthorn; 30 grams on a 600-pound Afrikaner. The winter coats contained 505 and 129 grams of hair, respectively.
4. Less capacity of the digestive tract.

Still undetermined physiological functions and adaptations may be involved in the heat tolerance of tropical cattle.

Cattle Breeding

The responsibility of the purebred breeder is to supply commercial producers with bulls that are uniformly prepotent for siring cattle of the higher market grades, capable of converting feeds into beef economically. To make progress, the breeder must have his objectives clearly in mind and must study the needs of commercial cattlemen. The cattle not only must be adapted for practical conditions of production, but must satisfy market requirements. Since commercial cattlemen encounter these problems to a greater extent than average breeders, they can, if well informed, greatly influence the trend of purebred selection through their preferential purchase of bulls.

Some of the more important market and production factors in beef-type selection are summarized in the following paragraphs.

Market Factors in Beef-Type Selection

Weight. For slaughter steers, the widest outlet at favorable prices has been for carcasses weighing 500 to 650 pounds, with 25 to 30 per cent fat in the edible portion. These correspond to good and choice to prime grades and to live weights of 850 to 1,100 lbs. Heifers, with similar feeding, reach the desired carcass composition at lighter weights than steers. A primary objective, therefore, is to breed cattle that will attain this carcass composition (degree of fatness) at these desired weights under practical conditions.

Yield of Wholesale Cuts. The variation in value of carcasses fat enough to satisfy the requirements of a given grade depends much upon the proportion of the wholesale cuts. Each cut differs in the characteristics of muscle fibers, or per cent of bone or both, and therefore sells at a different price. Good and poor carcasses are compared in figure 2 (II). Data (5) on choice feeder steers (2– to 2 grade) fed to good-grade slaughter condition yielded 59.3 per cent of higher-priced round, rump, loin, and prime rib cuts and 40.7 per cent of lower-priced flank, plate, brisket, foreshank, and chuck. According to Davis (6), the average yield from good-grade steers is 54 per cent of the good cuts, and 46 per cent of the poorer. With the higher-priced cuts at 26 cents per pound and the lower at 19 cents—a common spread—the difference in yield shown above amounts to 40 cents per 100 pounds, or $2.40 on a 600-pound carcass.

Other California Experiment Station data for cattle grading from good to choice as feeders showed comparatively small differences (less than 0.6 per cent) in cut-out value; this was true also between good-choice Herefords, crossbred Brahman-Herefords and Brahmans. Thus, in type and outward appearance, animals can vary markedly without materially altering carcass value due to conformation so long as they are straight, trim, and well balanced. Excessive weight in shoulders and excessive depth in relation to length increase the proportion of cheaper cuts.

Shape of Wholesale and Retail Cuts. Desirability and salability depend much upon the shape of the cut. From the standpoint of cooking, carving, and serving, short thick cuts are preferable to long thin ones. Variations in shape are shown in the carcasses in figure 2 (II) and in the rib cuts, figure 3 (II). Low-set, wide, thick body conformation, with heavy muscling of back, loin, and hindquarters and heavy weight in relation to height, are outward manifestations of short bones and thick cuts.

Proportion of Meat to Bone. The housewife, the principal meat buyer, is particularly sensitive to the amount of bone apparent in a cut. In contrast to long bones and thin muscling, the shorter, thicker cuts give the impression of more lean in proportion to bone. In a comparison of 55 beef-type and 80 dual-purpose-type Shorthorn steers (7) the former averaged 28 per cent bone and 72 per cent muscle in the ninth, tenth, and eleventh rib cuts; the latter, 30 per cent bone and 70 per cent muscle. Other data show that there is a high correlation between the composition of these cuts and the rest of the carcass. The extreme range in bone to muscle proportion for individuals of the 135 head was from 36 per cent bone and 64 per cent muscle, to 21 per cent bone and 79 per cent muscle. Some significant differences were also found for the steers from different sires. The extreme range shows an opportunity for selection. The difference between the average of the milking type and the beef type, however, was not great. Only small differences in proportion of lean to bone have been found in broad-breasted chickens and turkeys compared with more angular types (8).

As Hammond's (9) extensive studies show, selection for shorter bones and thicker fleshing results in greater diameter and thickness of bones, so that pro-

portion by weight is little changed. Hammond found as much muscle in relation to bone in sheep of the semiwild type as in improved breeds. Some improvement in the muscle to bone ratio might be obtained by selecting for thick muscling and fine bone. This, however, would tend to reduce size. Improvement, therefore, ap-

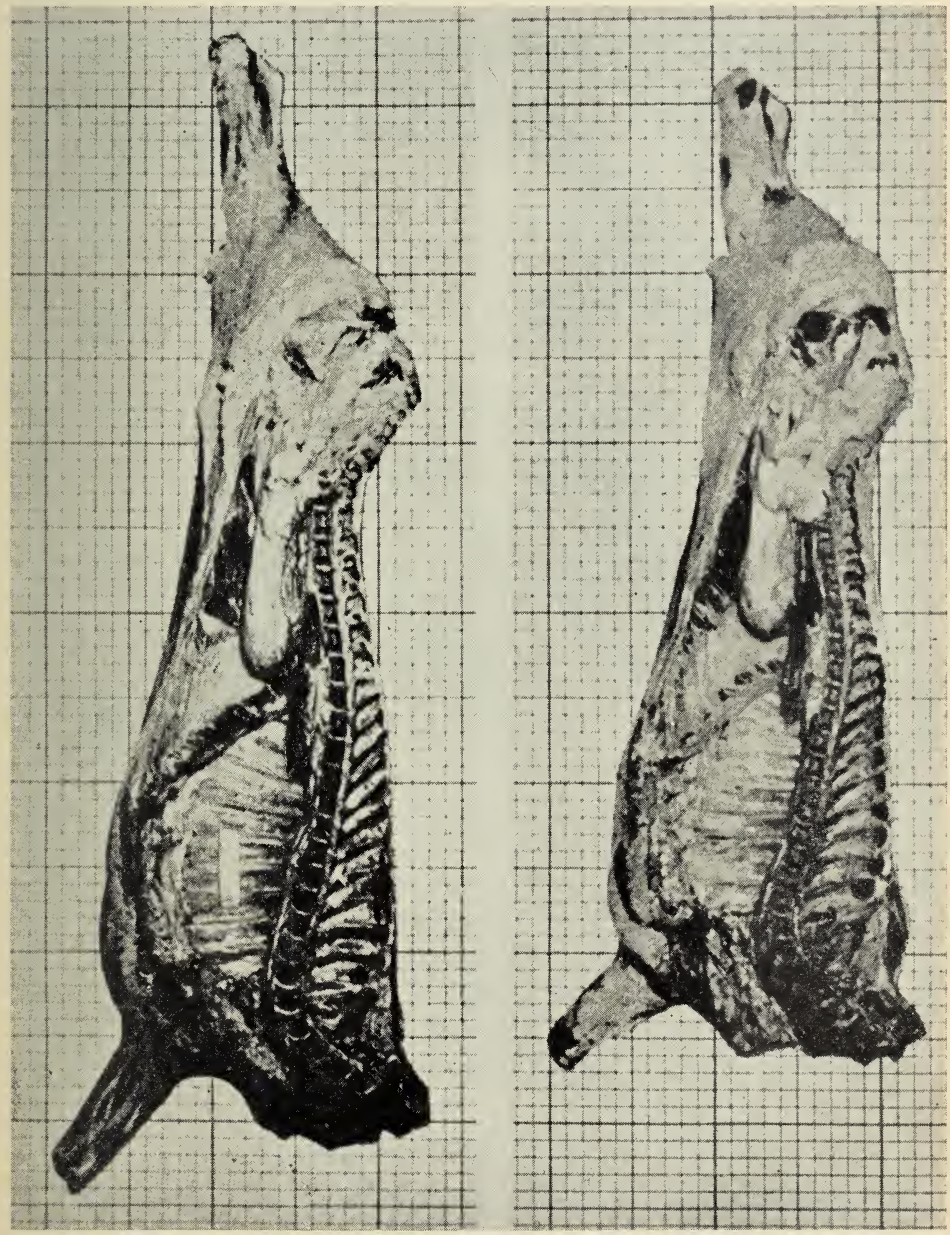


Fig. 2 (II). Examples of (*left*) undesirable and (*right*) desirable beef carcasses. The poor carcass has too much length compared with thickness; it is heavy in front, light in the rear quarter, and flat-sided. The good carcass is shorter and thicker with less cheap meat in the shanks, neck, and ribs. (From: Hammond, J. Farm animals; their breeding, growth, and inheritance. 199 p. Longmans, Green & Co., New York, N.Y. 1940. By permission of the publisher.)

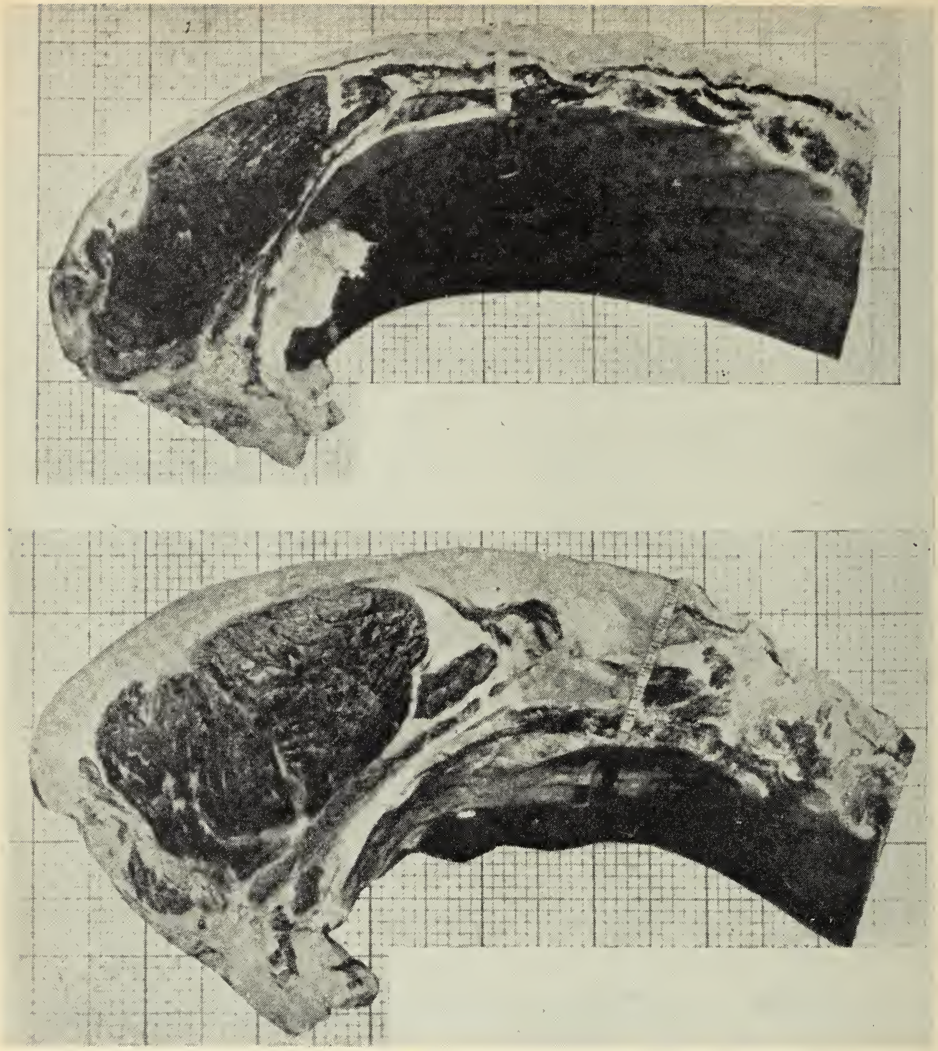


Fig. 3 (II). Cuts through the ribs of the carcasses shown in figure 2 (II). *Upper:* undesirable cut; shallow "eye" muscle and large proportion of bone to edible meat. *Lower:* desirable cut; deep-fleshed with small proportion of bone to edible meat. (From: Hammond, J. Farm animals; their breeding, growth, and inheritance. 199 p. Longmans, Green & Co., New York, N.Y. 1940. By permission of the publisher.)

pears somewhat limited, not only because of existing variation for selection, but also the necessity of having reasonably good bone to meet production requirements. On this question, more data are needed. If boning of carcasses becomes a more general merchandising practice, the yield of meat will assume greater direct economic importance for processors and producers.

The proportion of fat-free lean to bone increases during growth, and the proportion of total edible meat to bone increases markedly with fattening.

Distribution of Fat and Lean. The ideal fat deposition is a moderate uniform outside covering over the whole carcass, a minimum of internal (including kidney) fat, with abundance of fat interspersed between the muscle fibers. This

ideal is illustrated to a remarkable degree in figure 4 (II), showing the rib and round cut from the carcass of an Aberdeen Angus International grand champion. The genetic factors for such distribution of fat are more generally encountered in Aberdeen Angus than in other beef breeds. The external indications are general plumpness of body; very smooth, firm appearance; and, under the hand, a feeling of firmness and resilience of thick flesh, in contrast to the softer, flabbier touch of excess external fat.

According to Callow (10), at Cambridge University, England, palatability of boneless prime rib increases with fatness up to a maximum of about 35 per cent fat and decreases thereafter. This optimum fatness corresponds with animals having carcass yields of 58 to 60 per cent of live weight. The proportion of fat is about twice that of protein in such a desirable cut!

Dressing Percentage. Carcass yield depends primarily on degree of fatness. Callow (10) has shown that for every 1 per cent increase in the dressing-out percentage, the fatty tissues of the carcass increased by 1.43 per cent. Variation in fatness accounted for 89 per cent of the total variation in dressing percentage under reasonably comparable conditions of fill. Deposition of excess mesenteric fat, which goes with the offal, tends to decrease dressing percentage. Animals having more length in relation to depth than has been considered ideal in the past, that are well balanced and solidly fleshed, with straight, trim bodies are capable of producing the high yields appreciated by the buyer at degrees of finish popular with the beef salesman and consumer.

In cut-out tests comparing individual Hereford steers, then in comparing these with Hereford-Brahman crossbreds, differences in live-weight value due to dressing per cent have amounted to $10 to $12 per head at 1,000 pounds live weight, while the maximum difference in value due to conformation as it affected cut-out value of the carcass was between $1 and $2 per head. Dressed yield is important in determining live-weight price, and is a constant bargaining point. Perhaps too much attention has been given to the $2 items and too little to the $10! Selection

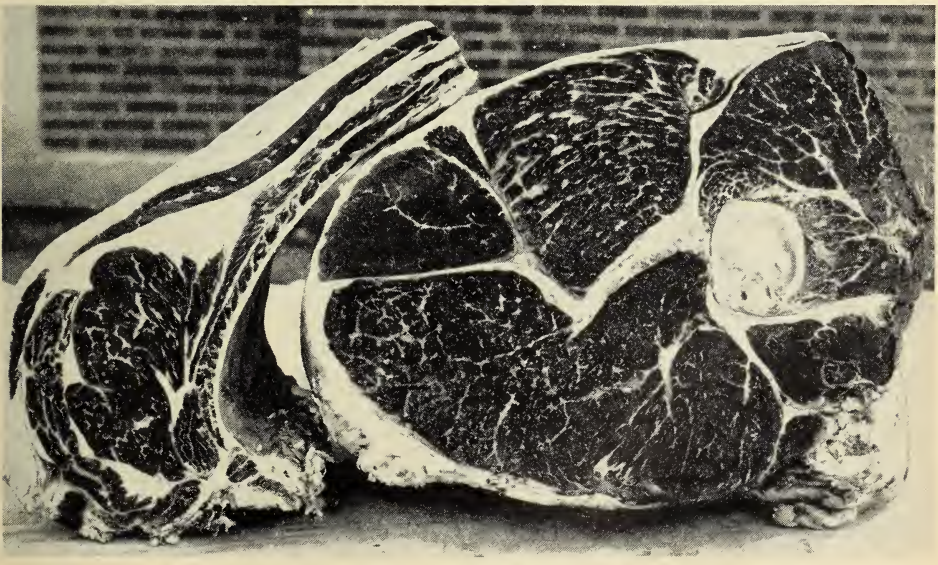


Fig. 4 (II). Rib and round cuts from an Aberdeen Angus International champion carcass. Note moderate but uniform external covering and excellent marbling. (Courtesy of Aberdeen Angus Breeders' Association.)

of beef cattle should emphasize more "good doing" cattle capable of dressing-out over 60 per cent at the moderate degree of fatness characterizing good slaughter grade.

For rapid and economical gains, feed capacity is essential. This can be obtained through reasonable length as well as depth. Thin-fleshed, fine-boned, shallow-bodied cattle may dress out well, but usually are poor feeders, slow in fattening. Such cattle can result from long periods of privation during earlier growth stages, as well as from poor breeding.

Production Factors in Beef-Type Selection

Size. There is no fundamental relation between size (potential mature size) and efficiency of feed utilization. Thus, there is little difference in over-all efficiency of sheep and cattle in converting feed energy to body substance. It has also been shown that smaller, very early-maturing steers may utilize their feed just as economically as larger steers, if both types are fed to the same degree of fatness. On the other hand, if the smaller type were fed to the same *weight* as the larger, they would be fatter and therefore would have required more feed for 100 pounds' gain because of the higher energy content of the increase. Significant variations in efficiency of feed utilization exist between individuals or within groups of cattle of different sizes.

If market requirements for carcass weight and finish remain relatively fixed, then, within limits discussed later, ideal size can in general be defined as the largest size which will, on a given plane of nutrition, attain the required carcass composition (degree of fatness) at the desired market weight. For example, large-sized "growthy" steers on range or pasture alone, or with a minimum of concentrate supplement, may weigh 1,200 pounds or more before attaining the most desirable degree of finish. The same steers on a higher plane of nutrition—that is, put on full feed in feed lots as calves or yearlings—would easily fatten enough at the more popular lighter weights. Somewhat smaller, earlier-maturing types that more nearly approach mature weight at about 1,000 pounds should be adapted to fattening at desired lighter weights on grass and a minimum of concentrates, because less demand for growth permits fattening on a lower plane of nutrition.

Similarly, economy involves the production of as large calves as the cows can support well. While small calves from small cows may be as economical as big calves from big cows, a big-cow overhead cost for small calves is uneconomical, just as 70-pound Southdown lambs out of Rambouillet or crossbred ewes are less profitable than the 85- to 90-pound Hampshire or Suffolk cross lambs that these ewes are capable of producing to a desirable market finish.

There are limitations in attempting to vary size to meet market requirements under different production methods and on different planes of nutrition. Extremes of any kind are seldom right. Huge size is usually accompanied by coarseness, poor fleshing qualities, loose rather than compact conformation, slow maturity and fattening; such an animal may be otherwise poorly adapted for harvesting feed and for production conditions. On the other hand, reduction in size and extremes of earliness of maturity accompany decrease in milk production, reproductive ability, and general vigor.

The medium within the range for the species or breed is usually the best from the standpoint of widest adaptability, general vigor, reproductive efficiency, milk production, and longevity. In good breeding condition, mature cows weighing 1,200 to 1,350 pounds and bulls weighing 1,800 to 2,000 pounds represent this medium-size range; but this weight must be obtained in the right way to satisfy all of the market and production requirements.

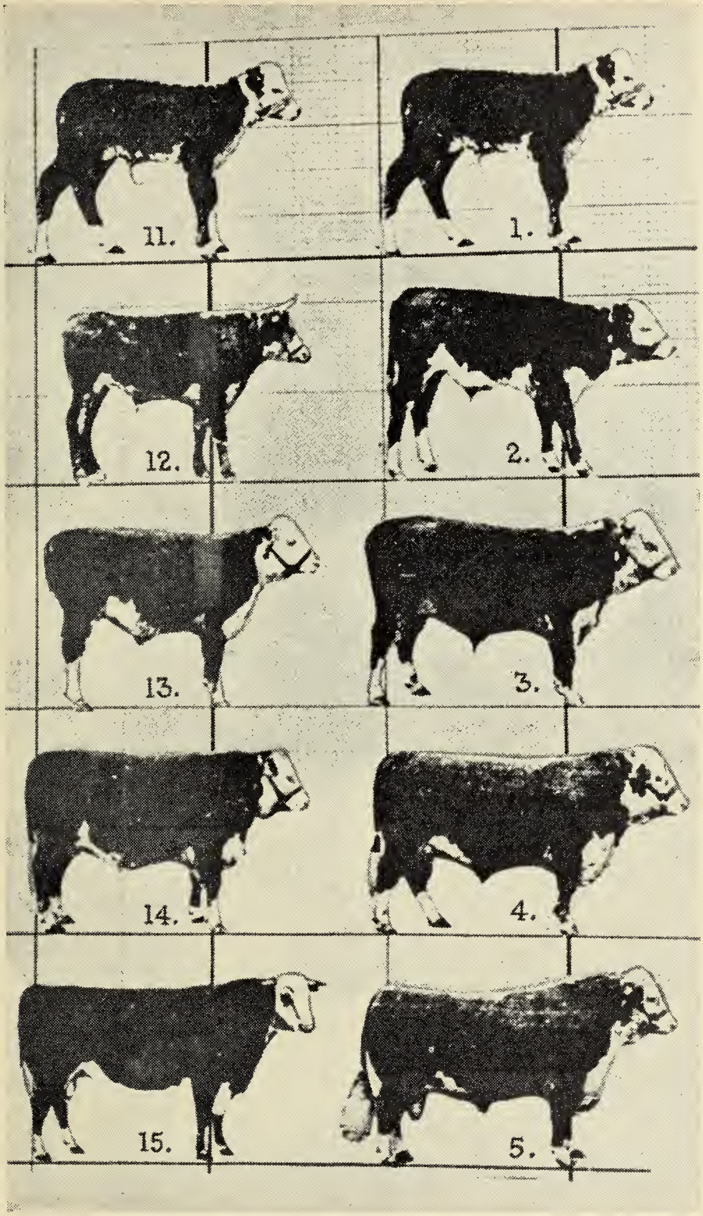


Fig. 5 (II). Changes in body proportion with age. To show these as distinct from changes in size, all photographs are reduced to the same height at the shoulders. *Left:* The proportions in animals of different ages and levels of feeding. No. 11, calf at 2 days of age; no. 12, steer 30 months old, on low level of nutrition; nos. 13 and 14, steers 11 and 22 months of age, respectively, on high level of nutrition; no. 15, a bull of about 100 years ago. *Right:* The changes in body proportion of bulls as they grew. No. 1, a calf at 2 days of age; no. 2, at 5 weeks; no. 3, at 13 months; no. 4, at 22 months; and no. 5, a mature bull of the modern type. (From: Hammond, J. Farm animals; their breeding, growth, and inheritance. 199 p. Longmans, Green & Co., New York, N.Y. 1940. By permission of the publisher.)

Conformation. To judge conformation at different ages, one must understand growth processes. Growth occurs in three overlapping phases: a peak of bone growth, a peak of muscle growth, and a peak of fat development. Changes in body proportion with age appear in figure 5 (II). To show the changes in body proportion as distinct from size, all the photographs are reduced to the same height at the shoulders. Pictures in the right-hand column show changes in proportion of bulls from 2 days to 5 years of age. Note the increase in thickness development with age; the calf has a relatively greater proportion of legs, head, and neck, but relatively little body depth, width, loin, and hindquarter, compared with animals at later stages.

Thickness growth, development of loin and hindquarters are late-maturing parts. The cannon bones enlarge and lengthen relatively less than the next bone above, and so on up the fore and hind limbs. Short cannon bones, which mean a low-set animal, have become recognized as a desirable feature of beef type and as indicating early maturity. This view is correct, because if this earliest-maturing part does not cease length growth early, later-maturing parts cannot be expected to develop rapidly. If, however, a calf is exceptionally thick and its proportions approach those of an average mature animal, it is destined to become either an exceptionally thick-bodied adult of moderate size or a moderately thick small animal. Most often the latter is what actually happens; the precociously mature and thick-appearing calves that frequently win in show rings tend to be disappointing in their later development. These changes of proportion with age must be kept in mind when one is selecting for type and conformation.

The left column of figure 5 (II) shows, in the picture second from the top (no. 12), that a steer 30 months old, grown on a low plane of nutrition, differed little in body proportion from a 5-week-old calf (opposite) on a high plane. Poor nutrition restricts the growth of later-maturing tissues more than it restricts skeletal growth and other earlier-maturing parts. This result clearly illustrates the necessity of providing adequate environmental conditions for full development of genetic possibilities; otherwise, selection may be inaccurate because of environmental effects. The next two pictures show the development of well-fed steers at 11 and 22 months of age. The lower picture (no. 15) illustrates a typical bull of about one hundred years ago; this, in contrast to the modern type on the right, indicates how greatly thickness growth and early maturity have been increased through selection and breeding.

Table 4 (II) gives weight and measurements of especially desirable Herefords at different ages and under favorable conditions for growth and development. These animals were not fitted, but were in good breeding-herd condition. These data may serve as a guide for desirable weights and proportions at different ages. Animals conforming rather closely to these measurements, however, still might not be desirable for breeding. For example, they might be lacking in symmetry and smoothness of conformation; deficient in breed or sex character; rough and open in the shoulders, low in the back, possibly sloping in the rump. While a good head in Herefords is usually about twice as long as the width at eye level, heads of this proportion might be considered poor if they showed a small, tapering muzzle; coarseness; lack of character, of femininity, or of masculinity. It is practically impossible to measure objectively all the external features that make up good or poor individuals; but those given may demonstrate some important features of good beef type.

Weight and thickness measurements increase over a longer period than linear measurements. Thus at 20 months the females attained about 75 and bulls 65 per cent of the mature weight, but both

TABLE 4 (II)

WEIGHT AND MEASUREMENTS OF PARTICULARLY DESIRABLE INDIVIDUAL HEREFORD CATTLE AT DIFFERENT AGES IN GOOD GROWING OR BREEDING CONDITION, BUT NOT FITTED FOR SHOW OR SALE

Animal number	Age	Weight, pounds	Height at withers, inches	Height at hooks, inches	Heart girth, inches	Length,* inches	Round measurement,† inches	Head		Width cannon bone,‡ inches	Grade	Condition
								Width, inches	Length, inches			
					Females							
819	2 weeks	105	26.4	27.2	30.4	26.4	22.1	5.1	9.9	1.0	2+	Good
819	8½ months	500	37.0	39.4	52.8	44.9	33.9	7.3	14.1	1.6	1−	Good
819	12½ months	705	39.0	42.5	60.9	52.0	36.6	7.9	16.0	1.8	1−	Good
773	16 months	825	43.4	46.0	63.8	52.8	37.0	8.3	16.3	1.9	1−	Good
773	20 months	935	45.6	47.5	68.6	53.2	40.8	8.5	16.6	...	1−	Good
773	24 months	982	46.1	47.7	69.4	53.6	42.2	8.6	17.1	2.1	1−	Good
14	3 years	1,170	48.1	50.0	74.8	58.0	43.8	9.7	18.3	...	1−	Good
14	4 years	1,340	48.5	50.0	78.0	60.0	44.6	9.7	18.6	2.1	1−	Excellent
14	5 years	1,310	48.5	50.0	77.0	60.0	43.8	9.7	18.9	2.1	1−	Good
					Bulls							
818	7 days	93	26.0	27.4	29.9	24.0	21.7	4.9	9.7	...	2+	Good
818	4 months	350	34.7	37.0	46.9	39.0	33.1	6.9	13.2	...	2+	Good
818	8 months	615	39.8	41.0	58.0	48.5	36.6	8.1	15.5	1.9	2+	Good
818	13 months	845	42.6	44.2	65.0	52.4	41.8	8.9	17.2	2.3	2+	Good
818	16 months	1,025	44.9	46.5	69.8	52.4	45.4	9.3	17.9	2.3	1−	Good
779	20 months	1,215	48.1	49.3	74.0	57.2	47.7	8.6	18.5	...	2+	Good
779	24 months	1,420	49.6	50.2	78.4	59.0	49.2	10.1	19.1	...	1−	Good
711	3 years	1,615	48.9	49.4	80.0	63.2	49.0	10.7	19.7	...	1−	Good
680	5 years	1,755	47.3	48.1	84.0	62.8	51.0	10 9	20.3	...	1−	Medium
680	6 years	1,910	47.3	48.1	86.0	65.4	51.0	11.2	20.4	2.6	1−	Good

* Length from the point of the shoulder horizontally to a line dropped perpendicularly from the pin bone.
† Round measurement is the horizontal distance from the point of the stifle joint on one side around the buttocks to the point of the stifle on the other side.
‡ Width of cannon bone is the width of bone and skin as viewed from the front midway of the length of the bone.

had reached about 95 per cent of height growth and 90 per cent of length growth. Round measurement and, especially, heart girth, vary with weight. Early-maturing animals in good condition, with well-developed hindquarters, have round measurements which in females are about 85 to 90 per cent as much as the height after 16 months of age; in bulls, 95 to over 100 per cent. Steers are intermediate between females and bulls in growth, size, and earliness of maturity.

Efficiency of Feed Utilization and Earliness of Maturity. Efficiency of feed utilization is controlled by a number of factors. These primarily involve or affect relative feed capacity, which means feed intake in relation to the amount required for maintenance. Animals having average maintenance requirements may excel in efficiency by being able to consume and convert greater than average amounts of feed in relation to their metabolic body size. On the other hand, animals of average feed consuming capacity may differ in efficiency through variations in their metabolic rates that increase or decrease the fraction of the total feed required for maintenance. This involves the endocrine system and in turn the disposition of the animal. Docile, quiet, or phlegmatic individuals are commonly recognized as "easy keepers." Experimental evidence indicates that both types of variability commonly occur in beef cattle and probably are of similar magnitude—logically so since the digestible nutrient requirement for maintenance is nearly half the total intake of cattle on full feed. Relative feed capacity is not merely the size and capacity of the gastrointestinal tract, although these may be involved. Appetite and total feed consumption are fundamentally affected by digestion, absorption, and storage capacities for food nutrients, as influenced by internal stimuli for growth and development and by the ability to dispense readily with the excess heat incident to high intake and conversion of feed.

Although high rate of gain and increased efficiency are frequently highly correlated, this is not always true. In a California test of the get of 4 sires, each consisting of 10 steer calves, there were lots that gained at the same rate but differed in efficiency, and lots with the same efficiency that gained at significantly different rates. Thus, actual rate of gain and efficiency were poorly correlated. There was a direct correlation, however, of relative feed intake and relative rate of gain with efficiency. From this, one may assume that maintenance requirements of these steers were essentially equal. These lots by different sires varied considerably in potential size and in the weight at which they reached an equal degree of fatness. In contrast with this are the results of individual feeding tests with 14 bull calves by one sire and with 7 by another. The get of the first sire were consistently more efficient than those of the second. The first group actually ate less per day than the second, although they gained and weighed more and reached equal finish. Moreover, between individuals there was a negative correlation between relative feed intake and efficiency. This strongly suggests that the get of one bull required less for maintenance—were truly more efficient in converting of feed. Furthermore, practically all of the offspring of this sire are notably gentle, quiet, and easily handled as well as being strong feeders. This was also ascertained by grade calves fed out before the bull was used as a herd sire.

Work at the Bureau of Animal Industry Station at Miles City, Montana, and by the Montana Agricultural Experiment Station indicates that the efficiency of feed used by individual bulls is highly heritable—the performance of the individual is a good index of the performance of his offspring. If further critical work confirms these findings, then progeny testing for this important factor in beef-type selection would be unnecessary and "official" feeding tests and indexing of bulls

on this and other factors of desirability may become a dominant factor in improving the usefulness of beef cattle. Indications of the possibilities are illustrated in figure 6 (II).

Degree of earliness of maturity may be defined as the rate at which an animal attains mature weight, conformation, and carcass composition. Figure 7 (II) illustrates some variations in the maturing of individuals in the University herd. The middle curve shows the average weight for age of Hereford females over a period of years. Number 602 not only gained more rapidly under the same environmental conditions, but also developed thickness, mature conformation, and composition earlier than the average; yet she attained the average weight for the herd. To accomplish this high rate of gain and yet thicken and fatten, she must have had a high relative feed capacity. Selection for early-maturing variations of this kind (that is, without sacrifice of size) automatically improves feed utilization and has definitely been responsible for much of the improvement made in the past.

Fig. 6 (II). *Upper, left:* This herd sire was bred by the University and proved in the San Joaquin Experimental Range herd. His steer calves exhibited outstanding performance in the Fontana Ranch feed lots. He was then used for several years in the University purebred herd. His sons were fed individually from 9 months of age for periods of 120 to 165 days—until they reached choice condition. The average weight at 8 months was 642 pounds; at 12 months, 930 pounds. The average feed for 100 pounds gain was 705 pounds; the average daily gain, 2.59 pounds. *Upper, right:* A son that weighed 685 pounds at 8 months; 950 pounds at 12 months; gained 2.83 pounds daily during the feeding test; and made 100 pounds gain on 688 pounds of feed. *Lower:* In turn, his sons, in a coöperator's herd made an average daily gain of 2.57 pounds during a 181-day feeding test and required 645 pounds of feed for 100 pounds gain. (Photo by Reuben Albaugh.)

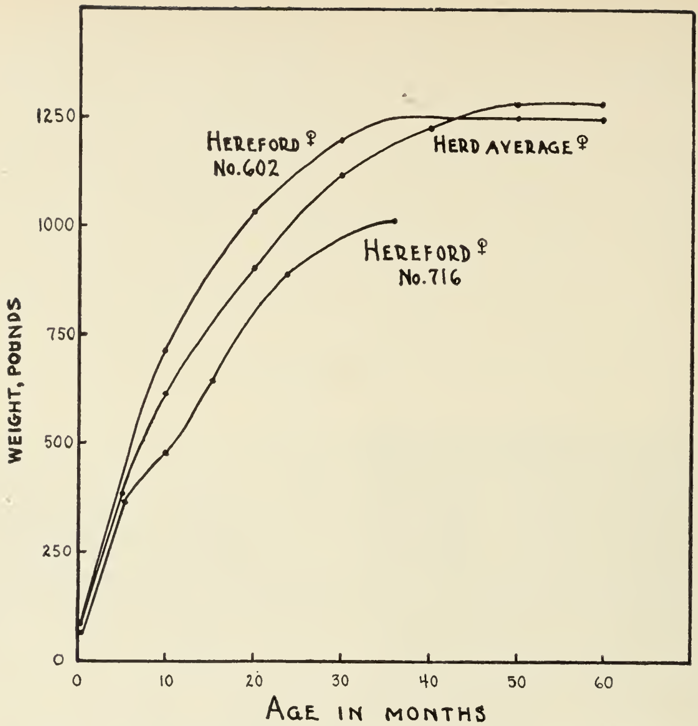


Fig. 7 (II). Early maturity variations in Hereford cows. The middle curve represents an average weight curve for the University herd. No. 602 gained more rapidly yet matured earlier than average at about average size. As a feed utilizer, this animal was doubtless more efficient than the average. No. 716 matured earlier than the average but was small, slow in gaining, and probably about average in efficiency of feed utilization.

Number 716 (fig. 7, II) gained more slowly, but matured earlier than the average, at a much smaller weight. She probably had about average relative feed capacity and efficiency. This type of increased earliness of maturity would be advantageous only where market finish was demanded at a lighter weight under good nutrition, or where the same finish was wanted at average market weights on a lower nutritional plane. By the time this animal weighed 800 pounds, she conspicuously slowed in general growth and could therefore fatten readily on a lower plane. This example illustrates the fact that selection for extremes in earliness of maturity generally leads to decrease in size.

Environmental Adaptation. Environmental adaptation involves all the factors influencing the ability of animals to thrive in the area where they happen to be. It includes ability to utilize the feed supply, to travel necessary distances for feed and water, to go from winter to summer range, and to withstand the prevailing climatic conditions. In the past, much more consideration was given to improving the environment to suit the cattle than to breeding cattle to suit the environment, except where conditions of temperature and disease compelled attention to the problem. The use of tropical cattle, Brahman and their crosses, in areas of high temperature is an example of this practice.

From the standpoint of the producer and of the general welfare, ability of an animal to thrive is more important than ability to conform closely to some ideal standard of conformation, color, or type

of hair coat that may be popular. Within an area, however, selection of animals that measure up to a standard of weight and conformation automatically tends to retain, for breeding, the individuals best adapted to the climate. If, for example, short glossy hair of uniform diameter is advantageous in hot areas, then selection of the best individuals for breeding may result in a herd of cattle having short, sleek coats. Conversely, a long woolly, dull coat prevents excessive heat loss during severe winters. Selection of the cattle that thrive in cold climates has resulted in this type of hair.

For efficient production one should not only find practical ways of improving the environment—through shelter and supplemental feeding—but also select the cattle best adapted to that environment. In purchasing breeding stock, one may secure better results by obtaining, from an area having similar climate, animals that meet the required standards and that have been selected in that area for a long period. Too frequently stockmen go a long way from home for breeding stock, without regard to climatic differences.

The Shorthorn, Aberdeen Angus, and Hereford breeds all originated in Great Britain and descended from cattle native to northwestern Europe, where the temperature fluctuations average about 35° F in winter, 65° in summer. Conditions similar to those where the breed was developed and improved through selective breeding are usually the most favorable to well-being.

In an earlier section were discussed the sources of body heat, the mechanisms of conservation and disposal to maintain normal temperature for physiological processes, and certain data bearing on the problems. Whenever the heat from atmospheric temperature, the radiant energy from both the sun and ground, and the internal heat caused by digestion and metabolism of feed exceed the capacity of the heat-disposal mechanisms, then the body temperature rises, feed consumption decreases, rumination ceases, and body movements are restricted except for the convulsive, rapid, shallow breathing to increase cooling through water evaporation from the respiratory tract.

Figure 8 (II) gives average monthly temperatures for certain areas in California through the year. These averages, though a useful basis for generalization, have limitations. For example, the day-to-day maximum-minimum range and the amount of exposure to sun radiation are important. Animals and men can endure longer periods of heat in the daytime if the night temperature falls considerably below the upper critical level for the individual and if cooling of the deeper tissues and resting of the regulating mechanisms are permitted. The shaded area (fig. 8, II), ranging from 35° F winter to 65° average summer temperature, may be considered ideal for temperate-zone breeds. Coastal regions, northeastern California, and higher elevations of the state generally fall within this range. An average monthly temperature of 75° may be considered about the upper limit for any extended period that does not result in depressive effects. At Davis, for example, the curve is within this range and is fairly typical of the center portion of the Great Valley. Only during July and August does the average monthly temperature reach or exceed 75° F. The nights are usually cool. With adequate water, some provision for shade, and a feed supply that can be obtained without too much time spent in traveling and in grazing, the high temperature will limit production only for short periods. The effects of high summer temperature on late-spring calves, however, are noticeable.

The temperature ranges shown for Chico and Bakersfield are representative of the northern Sacramento Valley, the middle and southern San Joaquin Valley, and the adjacent lower foothills. For 3 to 5 months in these areas, the average monthly temperature exceeds 75° F, and

for 2 months it reaches or exceeds 80°. Since the livestock industry is accustomed to feed or weather conditions that restrict gains, it has not been too much concerned about these periods. Judging from data gathered in other parts of the world and from observations in these areas, however, high temperature does significantly affect production. Certain difficulties now attributed to feed supply and other factors may really be due to temperatures that exceed the tolerance of the cattle. In such places, attention should be given not only to feed, water, and shade, but also to selection of better-adapted cattle from the temperate-zone breeds.

The upper curves in figure 8 (II), showing readings at Blythe and Brawley, are representative of the subtropical conditions of the Palo Verde and Imperial valleys. Here the average temperature stays above 75° F for 6 months, exceeds 85° for nearly 4 months, and reaches 90° for 2 months. Clearly, this is outside the adaptation range of temperate-zone cattle. During the summer, even under favorable conditions of irrigated pasture feed, gains are seriously restricted. For year-round beef-cattle production in these areas, increase of heat tolerance through crosses with tropical breeds is indicated. A start has already been made. Further progress may also be possible in developing artificial means of maintaining lower body temperature of the animals.

If the several environmental influences and the characteristics indicative of the corresponding adaptabilities of animals are known, then the breeder can make positive selection accordingly. Some of the more important information on characteristics related to climatic adaptation may be summarized as follows:

1. There is evidence of some variation in heat tolerance between individual members of the common beef breeds. Data obtained in South Africa and in the United States indicate that the breeds may

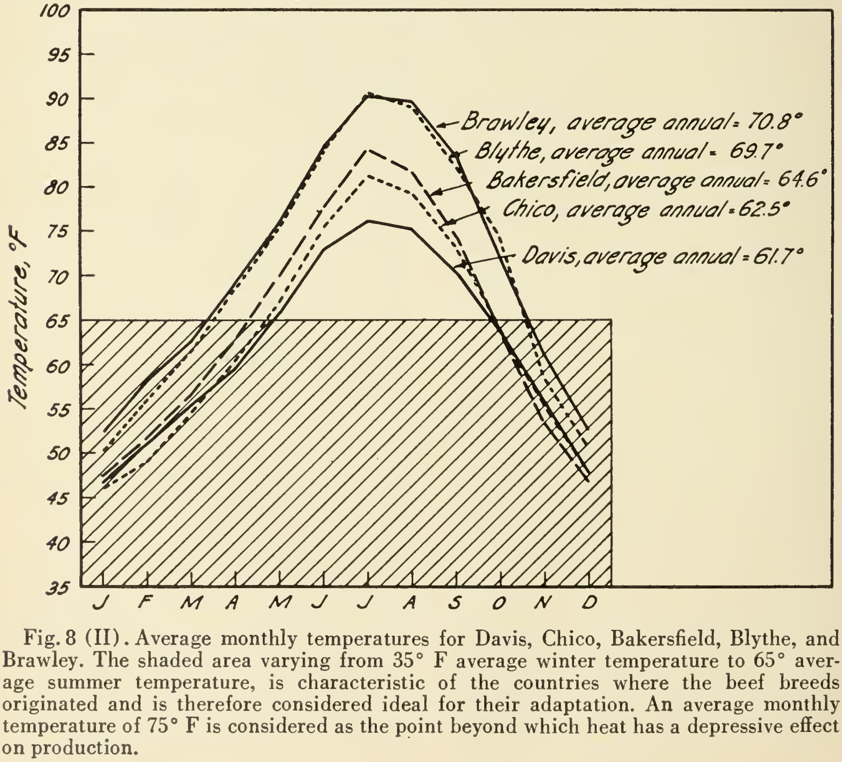


Fig. 8 (II). Average monthly temperatures for Davis, Chico, Bakersfield, Blythe, and Brawley. The shaded area varying from 35° F average winter temperature to 65° average summer temperature, is characteristic of the countries where the beef breeds originated and is therefore considered ideal for their adaptation. An average monthly temperature of 75° F is considered as the point beyond which heat has a depressive effect on production.

rank in the following order of decreasing heat tolerance: Hereford, Shorthorn, and Aberdeen Angus. The data were based upon small samples and may not be representative of the breeds as a whole. Two samples taken in different parts of the world, however, gave essentially the same results. The apparently greater heat tolerance of Herefords is probably a factor in their predominance in the Southwest. Brahman and Afrikaner cattle that originated and were developed in the tropics have high heat tolerance. Crosses between them and the temperate-zone breeds tend generally to have heat resistance that is intermediate and proportional to the percentage relationship to the parent types.

2. Respiration rate, pulse rate, and body temperature are good indices of heat tolerance. Conditions are most favorable when heat regulation is accomplished largely by radiation, by conduction to the surrounding air, and by evaporation of water from the skin surface. Conditions become progressively unfavorable for the animal as increased respiration and blood circulation are called into play to dispose of heat by assisting greater water evaporation. The respiration rate is easiest to determine, and observations made under comparable conditions of exposure in sun or in shade at temperatures of 90° F or higher have value for selection purposes. Respiration rates between 20 and 50 per minute are characteristic of comfortable conditions for cattle. Differences in rates between temperate-zone breeds and tropical cattle increase sharply at 80° and above. Rhoad (11) suggested an index based on rectal temperature of animals exposed for a definite time in the sun with air temperature (shade) in the 90° F class. The normal rectal temperature average (101° F) is subtracted from the rectal-temperature reading, multiplied by 10, and subtracted from 100 to give a relative index 100–10 (BT–101). A score of 100 represents no temperature change, or perfect adaptation under the test conditions. The following data were thus obtained: purebred Brahman, 93; ½ Brahman, ½ Angus, 89; purebred Jersey, 86; ¼ Brahman, ¾ Angus, 76; grade Hereford, 73; purebred Angus, 56. A breeder interested in the problem might classify a whole herd of purebreds in this way within a short period. Body temperature of temperate-zone breeds may rise to 106° F or more on hot days (90° F and above), especially when the cattle are exposed to direct sunlight.

3. The amount of loose skin characteristic of Brahman cattle may contribute to their greater heat tolerance. Increased skin area for heat transfer to the surrounding air is advantageous as long as air temperature is lower than body temperature. This factor may be involved in the apparently somewhat greater tolerance of Herefords; for hot climates, the tendency to breed away from loose skin on throat, dewlap, and brisket may be a mistake.

4. Coat color and character play a role in climatic adaptation. Light coat color reflects more sun and sky radiation than dark color and thus prevents a larger portion from being transformed to heat at the body surface. The heat from radiation in a 15-hour summer day may be two to three times as much as internal heat from metabolism (12). How much is actually absorbed by the animal, or how much is dissipated from the hair and skin surface to the surrounding air, has not been determined. Penetration of the heat produced depends on the type of hair coat, the skin pigmentation, and perhaps other factors.

The ideal for heat tolerance would appear to be light or white hair color over a dark-pigmented skin, such as commonly occurs in tropical cattle. Dark skin keeps out the actinic rays, excess of which would damage the deeper tissue layers. White color in common beef breeds is associated with white skin, which is susceptible to sunburn and photosensitization, and which in Herefords predisposes

to eye cancer. Breeding for red pigment on the eyelids of Herefords would not appear to impose much difficulty and would be a factor of considerable economic importance.

Under glaring midday light, white Brahmans were found to reflect 22 per cent of sun radiation, light fawn Jerseys, 14 per cent, Red Santa Gertrudes, 4 per cent, and Black Aberdeen Angus, 2½ per cent. For low light intensity, the percentage reflection was 55, 40, 20, and 10, respectively (13). Similar observations were made in South Africa (14).

Short, straight, glossy hair coats reflect more radiation than duller, curly, or woolly coats. The latter act as insulators by trapping a layer of "dead air" around the animal and thus tend to prevent heat loss. This characteristic is desirable for cold climates, undesirable for hot weather. Clipping hair from cattle makes them more comfortable at high temperature in the shade; but in the sun they suffer more than unshorn cattle, whose hair provides much protection.

It has been reported that cattle with higher heat tolerance (Afrikaners) have thicker skins and more hair fibers per square inch than those poorly adapted (14). The skin of Brahman cattle, however, has been found to be thinner than that of common breeds, but denser in texture.

A summary of tests in South Africa (fig. 9, II) gives results with two groups of temperate-zone cattle selected, when calves, on the basis of hair coat. Under otherwise comparable conditions, those with glossy short coats had rectal temperatures 1 to 1.5 degrees lower than those with woolly coats when the air was 90° to 100° F. Corresponding differences in pulse and respiration rates were observed. Even in the shade, the glossy animals maintained lower temperatures because of greater efficiency in losing heat from the skin surface. Curly-coated calves that did not shed before hot weather, failed to do so during the summer. Poorer heat tolerance resulted in low nutrition, which interfered with normal shedding, so that a vicious circle was set up. At 2½ years of age there was an average difference of 193 pounds in weight in favor of the glossy-haired group.

Thus, selection for short, straight-haired cattle with a tendency to shed early is indicated for hot climates. For cold countries a longer coat, with a finer undercoat of curly or furry hair efficient for heat conservation, is desirable. Although the hair of the same animal is greatly modified by climate, as evidenced by difference in summer and winter coats, there is good opportunity to select in the directions desired.

5. Some characters that contribute to general adaptation are conformation of legs, and texture and shape of feet. Straight, strong legs and good feet, conducive to free and easy stride, are important in the traveling required to obtain feed and water. Many defects of both fore and hind limbs are found in the beef breeds. A very common defect is the sickle-hocked condition, with lack of bone and tendon support below the hock. This may become greatly accentuated with heavy feeding, excessive weight, and too little exercise; and it may interfere not only with traveling, but also with breeding efficiency of bulls. Cattle with sore feet do not thrive under any conditions. Some hoof textures are susceptible to cracking and overgrowth, whereas others are fine and dense, yet wear evenly. Well-shaped feet have parallel toes with little tendency to spread apart under the animal's weight. A common defect is the tendency for the ends of the toes to curl inward, widening the interdigital space—a condition that increases chances for mechanical injury and subsequent infection.

Constant selection to eliminate these faults is necessary, particularly when they are more or less characteristic of the foundation cattle of a breed.

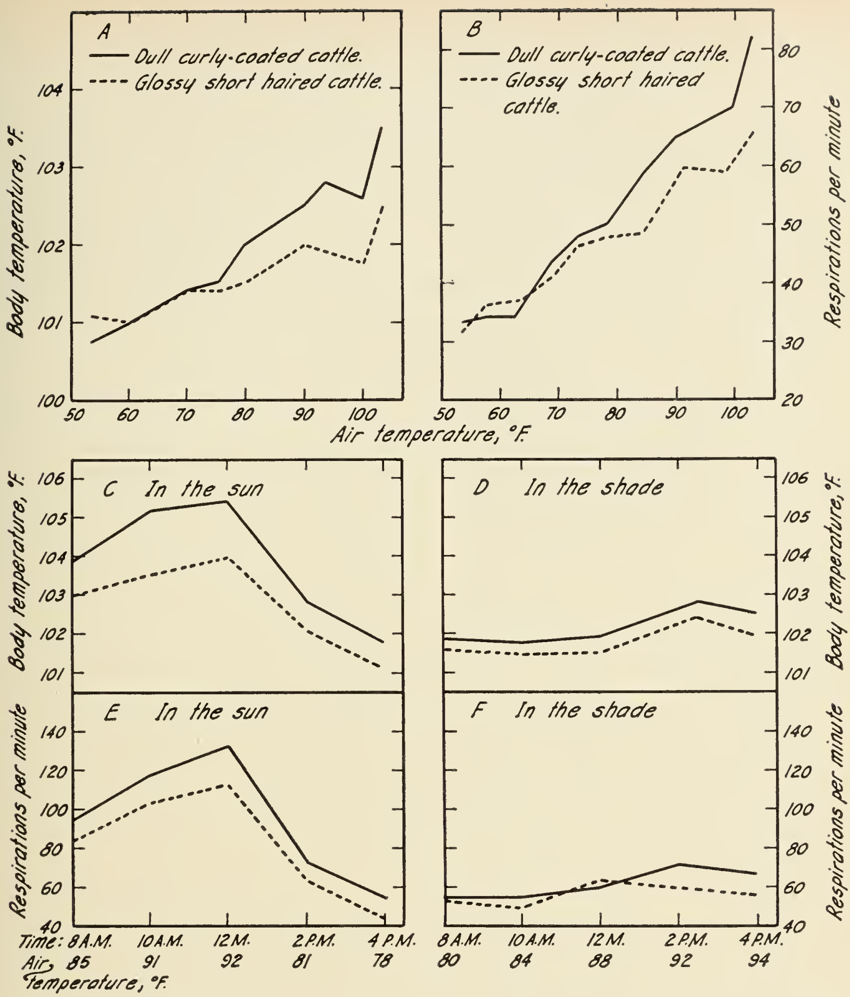


Fig. 9 (II). Effects of type of hair coat on body temperatures; and respiration rates at different environmental temperatures, with animals exposed to direct sunlight and under shade. (Adapted from: Bonsma, J. C., and A. J. Pretorius. Influence of colour and coat cover on adaptability of cattle. Farming in So. Africa, 18:101–20. 1943.)

Reproduction. Reproductive ability is fundamental to economical beef production. Large variations are usually the result of poor feed or disease. Certain differences in regularity of breeding, abortions, and stillbirths, however, appear to be hereditary. The long-time average for Herefords and Shorthorns in the University purebred herd at Davis, the supplementary fed Hereford herd on the San Joaquin Experimental Range, and the large Hereford herd at the United States Range Experiment Station at Miles City, Montana, varied from 85.6 to 89.6 per cent pregnancies and from 81 to 83 per cent calf crops weaned. Over a seventeen-year period, the Aberdeen Angus herd at Davis had 94.7 per cent pregnancies, and 85.5 per cent calf crop weaned. On the average in the University herds, 56.8 per cent of failures were dry cows, 11.1 per cent were stillbirths or calves that died shortly after birth, 3.9 per cent were deformed, 16.4 per cent were abortions (not caused by brucella infection), and 11.8 per cent were calf

losses from accident, disease, and miscellaneous causes before weaning. Judging from the evidence presented in a later section on selection and culling of cows, some of these failures may be hereditary; carefully kept records may reveal the problem and suggest bases for improvement. A tendency for prolapse of the vagina was one important cause of reproductive failure and loss in Hereford cows or for discarding them from the breeding herd. In cattle, evidently, a breeding efficiency approaching 95 per cent pregnancies is possible. Differences in fertility are also common in bulls and are especially revealed by records kept and semen studies made in artificial insemination. Occasional bulls are sterile even though sexually active.

Longevity. Since most beef females are not permitted to start reproducing until about three years of age, the length of the productive period thereafter has an important bearing upon the overhead cost of developing breeding stock in relation to the number of calves produced. The longer the good, proved, producing cows can be kept without sacrifice of calf crop or too much decrease in salvage value, the less the percentage replacement required. The proportion of younger animals that can be marketed is correspondingly increased. Over a twenty-one-year period, the average age of discarding from the University purebred herd for all causes was 9.1 years for Shorthorns, 9.5 for Herefords, and 11.9 for Angus. The Angus averaged over two more calves during the breeding life of the cows. Individual data on Angus longevity is cited in the section on selection and culling. Longevity is apparently more common in Angus cattle. Probably no cow has surpassed the record of the famous "Old Granny," who lived to 36 years of age and dropped her twenty-fifth calf when she was 29. Selection and improvement to extend longevity in this regard are possible in all breeds and should receive more attention.

Lactation. The importance of good milking cows in producing heavy, thrifty calves is appreciated by most commercial producers. Unfortunately, insufficient attention is given to this factor by some purebred breeders; and the widespread use of nurse cows to develop the better prospects among the calves unfortunately perpetuates poor milking ability that might otherwise be eliminated. One can greatly improve milking ability by selecting bulls on the same basis recommended for dairy cattle. Some bulls transmit, with reasonable uniformity, superior milk yield to their daughters. The best method is to seek a bull whose dam and sire have both produced good milking daughters. Proved transmitting ability of the parents is the best recommendation for the prospective sire. If there is no opportunity to observe or to secure information on the daughters of the parent animals, then the milking ability of the mother and of the sire's mother is the next best criterion. Culling of poor milking cows should be constantly practiced. Its effect on average calf weight at weaning is discussed on pages 42–43 (II).

Records of Performance

The first and most important step in developing and applying a breeding program is to determine the characteristics and specifications of the ideal type. The data summarized under "Production Factors in Beef-Type Selection" should help to clarify such problems. Though present ideals can be illustrated in living animals, precise specifications are difficult to make, because the problem is complex. The producer or breeder must learn through continued observation on ranches, at sales, shows, feed lots, markets, and beef coolers; and through study of illustrative literature. The great breeders of the past have been men who visualized an ideal better than the current standards. The second step is evaluation of individual animals, and the third the selection and mating of superior stock.

Three breeding methods may be employed. The first, called mass selection, consists in choosing the best individuals by their appearance alone, without knowledge of ancestry. This is the usual procedure in commercial herds. Much progress is made in this way, because superior individuals often do transmit good characters to their offspring. One cannot tell with certainty, however, from outward appearance (phenotype) what the animal may transmit (genotype). Thus, two polled individuals may produce a horned offspring; two roan-colored parents may produce red, white, or roan calves; two blacks may produce a red. The same holds true for conformational and other characters of more direct economic importance. The second method is pedigree breeding, commonly used in purebred herds. Individuality and performance of the ancestors, as well as the animal's appearance, are relied upon for an estimate of the probable transmitting ability. If adequate information is available, this kind of breeding is a great step in advance. Too often, however, adequate information is lacking; and too much emphasis is placed upon fashionable names and a sprinkling of noted animals more or less remote in the pedigree, rather than on the average excellence or lack of it in all of the ancestors in the first two or three generations.

If the sire has been proved, one need not be greatly concerned over what is back of him. His record for siring uniformly good cattle is in front of him and that is of chief importance, largely taking care of the top half of a given calf's pedigree. Further, if the calf's mother is by a good proved sire and from a good cow family, that fact is the best present information which can be obtained regarding her probable transmitting ability. The half brothers and half sisters, and other collateral relatives not shown in the pedigree, may be even more valuable indices than the direct ancestors. Thus, according to Rice (15), "Individuality tells us what an animal seems to be. His pedigree tells us what he ought to be, but his performance as a breeding animal tells us what he really is."

The third and more precise method of evaluation is to select on the basis of individuality and pedigree, determine transmitting ability for the characters desired, and then use as extensively as possible the animals with proved transmitting ability. More general uses of this third step in breeding can significantly increase future progress with beef cattle. To find the few bulls that have transmitting ability superior to the average, many bulls must be systematically tested. Progeny-performance breeding depends upon adequate records. As already mentioned, such records for meat animals are less simple or precise than weight of the milk and determination by chemical test of the quantity of butterfat produced by the dairy cow. Weight for age may be used as a measure of quantity of production; over-all evaluation by grading indicates the degree of excellence of the product, and the adaptation of the animal for production conditions. Although these methods have limitations, they can serve very well until more precise indices are available.

The need for some systematic, yet relatively simple, procedures for this purpose is evidenced by the fact that numerous breeders have evolved systems of their own. Because of the interest in the subject and the individual trial-and-error effort being made, a grading guide and a set of record forms are presented, in the hope that they may prove useful and constitute a step toward a uniform procedure. The grading guide and forms illustrated are the result of several years of study, experiment, and experience; they include the major items discussed under "Production Factors in Beef-Type Selection."

Grading. Grading is an attempt to measure all beef cattle with the same yardstick. It differs from ordinary judging in that it classifies an animal not only in

relation to the individuals in its particular group, but also in relation to the beef-cattle population as a whole. In show-ring judging, the top of the classes and champions represent the best of the animals that happen to be brought together; but their grade, or degree, of excellence is variable. The winners in the large shows are usually first grade; but even here a third- or fourth-place animal in one class may sometimes be superior to the top animal in another class. First-prize winners and even champions in small shows may grade rather low and may be considered not even good enough to raise the standards of commercial cattle.

The grading guide, table 5 (II), is a standard and a means of orientation when one is considering breeding and market animals. The terms used are familiar to breeders and commercial cattlemen. Grading is subject to errors in judgment. The value of the records depends upon the grader's knowledge and experience—the same knowledge that is prerequisite for good breeders, for no man ever breeds better cattle than he knows, appreciates, or can visualize. Experience has demonstrated that grading in accordance with this guide can be learned readily by stockmen. It is based upon market grades, with due consideration for breed, sex character, and other characteristics that are empirically associated with breeding ability. The numerical grades are based upon common occurrence of 30 per cent differ-

TABLE 5 (II)

GRADING GUIDE FOR BEEF CATTLE RECORDS OF PERFORMANCE

Grade designation	Numerical value	Description		
		Breeding cattle	Market cattle	
			Feeders	Slaughter *
Grade 1	100 (1+) 97 (1) 94 (1−)	The top of the grade represents outstanding animals in strong competition. The middle and lower end of the grade represent excellent breeding animals from standpoint of type, conformation, quality, and character, capable of making a good showing in strong competition	Strictly fancy or select	Top prime, capable of creditable showing in strong, single, or carlot competition
Grade 2	91 (2+) 88 (2) 85 (2−)	Cows in grade 2 are good enough to retain for breeding test in purebred herds. This is a practical top for commercial cattle. The top of grade 2 represents the best of range bulls; the lower end of herd bulls. Cattle in this grade are well down the line or out of the money in strong competition	Top choice Choice Low choice	Prime to Low prime
Grade 3	82 (3+) 79 (3) 76 (3−)	Cows usually should be culled from purebred herds; good commercial cattle; bulls rarely capable of making much improvement except on very plain cattle	Top good Good Low good	Top choice to Low choice
Grade 4	73 (4+) 70 (4) 67 (4−)	Plain, upstanding, thin-fleshed, slow-maturing cattle, lacking in quality and character and having serious defects of conformation. Should be culled from commercial herds	Top medium Medium Low medium	Good Commercial Low commercial

* Grade standards for carcass beef were revised and made effective January 1, 1951. The former U. S. Prime and Choice grades were combined and henceforth will be designated as **Prime.** The old grade of U. S. Good is now **U. S. Choice.** Young animals that formerly graded in the top half of U. S. Commercial will now be designated **U. S. Good.** Mature animals and those not otherwise qualifying for the top of the old U. S. Commercial grade retain the U. S. Commercial grade as before the revision. Qualification for U. S. Utility, Cutter, and Canner are unchanged. In general, younger cattle are required to have less finish and marbling in the muscle than older ones in the same grade.

TABLE 6 (II)

VARIATION BETWEEN THE FIRST GRADING AND SECOND GRADING OF THE SAME ANIMALS AFTER A YEAR'S INTERVAL

Age at last grading	No variation		One third of a grade		Two thirds of a grade		One grade	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Cows, 4 years and over	75	56.8	41	31.1	13	9.8	3	2.3
Heifers, 3 years	29	60.4	14	29.2	5	10.4	0	0.0
Heifers, 2 years	29	44.7	33	50.7	3	4.6	0	0.0
Heifers, 1 year	29	50.0	22	38.0	5	8.6	2	3.4
Bulls, 1 year	9	33.3	17	63.0	1	3.7	0	0.0
Total or average	171	51.8	127	38.5	27	8.2	5	1.5

ence in value per pound from the lower to higher grades of commercial cattle. The grades are assigned numerical values in steps of 3, giving a total range of 33 per cent. These numbers, or per cent grades, are useful for averaging and otherwise handling the data statistically. The grade designations 1–, 2, 2+, and so on, are easier to remember and use in the field.

Table 6 (II) summarizes tests covering 330 comparisons between two gradings of the same animals by the same graders, taken a year apart. These data show that about 52 per cent graded the same both times, 38.5 per cent varied a third of a grade, and less than 10 per cent varied more than this. Since many animals are borderline between grades and since cattle of all ages were included, the data show that grading may be done with a reasonable degree of repeatability when environmental conditions are relatively uniform. Poor feeding or other unfavorable conditions can result in conformational characteristics more or less indistinguishable from those produced by poor breeding and thus may complicate grading or make it inaccurate as a measure of hereditary differences.

Grading is a valuable means of analyzing the herd, of knowing a large herd better, and of recording information on all cattle and their offspring instead of depending upon memory, which at best is not a permanent record. Grading records can increase the pedigree information to a more useful level and, in superior pedigrees, can be of commercial value.

Some herd analyses are given in table 7 (II). As this table and grading chart indicate, the first two herds must be culled extensively if the owner wishes to avoid producing bulls that are incapable of making improvement except on very plain cattle. The third herd contains a higher proportion of acceptable cattle, and only moderate culling is required.

Data from herd 1 show the advantage of using both production records and individual selection in culling, instead of working on the basis of individuality alone. According to these figures, the produce of 79 dams grading 2– (85) and over, averaged 83.1 in grade, while the produce of 110 dams grading 3+ (82) or below averaged 81.8. A large percentage of cows fell into the upper end of grade 3 and the lower brackets of grade 2. The average of the calves tended strongly toward the average of the herd, as usually happens unless a very prepotent bull is found. Given the same bulls, small improvement would have been made by culling all cows below grade 2—. Retaining the good producers from the 3+ cows, and eliminating some poor producers from the grade 2– and better cows, resulted in a group producing 68 per cent of calves in the grade-2 range, compared

TABLE 7 (II)

ANALYSIS BY GRADES OF THREE HERDS OF BREEDING COWS

Grade designation	Herd no. 1			Herd no. 2			Herd no. 3		
	Number of head	Per cent of total		Number of head	Per cent of total		Number of head	Per cent of total	
+	0	0.00	1.71	..	....		0	0.00	10.6
Grade 1	1	0.57		..	....		2	1.90	
−	2	1.14		..	....		9	8.70	
+	12	6.86	36.57	11	3.80	44.90	17	16.30	63.4
Grade 2	18	10.28		29	10.10		28	26.90	
−	34	19.43		88	31.00		21	20.20	
+	53	30.28	61.72	110	38.60	55.10	22	21.20	26.0
Grade 3	48	27.43		45	15.80		5	4.80	
−	7	4.00		2	0.70		0	0.00	
Totals	175	100.00		285	100.00		104	100.00	

with between 40 and 50 per cent if the cows were selected on individuality alone.

The average prices in relation to grade of bulls and females sold in the 1945 and 1946 Red Bluff sales appear in table 8 (II). In general the purchase price varied directly with grade, and the price spread increased markedly for grade 2+ bulls, which, according to the grading chart, represent the top end of so-called range bulls and the lower end of the herd-bull prospects that are competed for, both by commercial cattlemen and by the breeders of purebreds.

TABLE 8 (II)

AVERAGE PRICES IN RELATION TO GRADE, RED BLUFF HEREFORD SALES, 1945 AND 1946*

Grade	Number of head		Percentage of total		Average price, dollars	
	1945	1946	1945	1946	1945	1946
Bulls						
1−	1	..	0.4	....	1575.00	.....
2+	33	16	12.3	6.6	656.00	912.00
2	48	59	17.8	24.2	438.00	524.00
2−	93	84	34.5	34.6	378.00	492.00
3+	67	84	24.9	34.6	302.00	395.00
3	27	..	10.1	....	253.00	......
Cows						
1−	..	2	....	2.7	......	1050.00
2+	3	2	3.8	2.7	992.00	1162.00
2	10	19	25.0	26.0	451.00	541.00
2−	25	50	33.0	68.6	397.00	398.00
3+	22	..	29.0	....	292.00	......
3	7	..	9.2	....	240.00	......

* In 1946, bulls grading under 3 plus and heifers grading under 2 minus were "sifted" and not permitted to sell through the auction ring.

Figures 10 (II) and 11 (II) show the front and back of record form no. 1; figures 12 (II) and 13 (II), record form 2; and figure 14 (II) record form 3, which is ruled the same on both sides. The system is predicated upon the basic factors in beef-type selection previously presented.

The procedure for keeping the records in purebred herds is outlined as follows:

Form 1, Get-of-Sire Record

1. Use a separate sheet for males and females.

2. Record, after a calf is born, the herd number, date of birth, number of dam, and her grade.

3. At weaning time, record date, weight, grade, and condition of each calf. Special feeding such as fitting for show or sale, should be indicated under "Remarks." The use of nurse cows is considered to have no essential function in practical beef production, but should be recorded.

4. Secure the same data on bulls 4 to 8 months after weaning; or, if the animals are sold before this age, give weight and grade at the time of sale. The time of the second weighing and grading will depend on the time when most bull sales begin. There are advantages in allowing as much development as possible before the final grading is done. Any females sold before the next annual grading after weaning should also be weighed and graded before disposal.

5. Weigh and grade all animals retained in the herd; do this once yearly until maturity. The time can be decided on the basis of convenience and favorable conditions for handling the cattle. The work should be done the same month each year and can coincide with one of the weighing and grading periods cited above.

6. Data recorded on the front side of the get-of-sire record will usually be limited to one year's calf crop. Data for the year can be summarized when complete for any age.

7. Summarize get-of-sire records as indicated on the reverse side of form 1. Both males and females and more than one year's calf crop can be included if desired. It will generally be well to summarize weaning data so that information may be secured as quickly as possible, and to use a second summary for yearling data, when the grading should be more reliable. An actual record illustrates the use of the get-of-sire summary (reverse side of form 1, figure 11, II). The graphic summary shows at a glance the average or general trend of get, compared with dams, and the "ceiling" grade of dams on which improvement can be made by the sire.

All essential data, except for heifers and cows retained in the herd, can be recorded directly on the get-of-sire sheets at the time of weighing and grading. Since only two sheets are required for each sire, the mechanics of recording are simplified, and the copying of records is avoided.

Form 2, Individual Life Record

1. Fill out all blanks possible on the front side of record for all females as soon as decision has been made to retain them in the herd. The pedigree and weight data blanks may also be used for sires retained for use in the herd. Grading and weight data are transferred to date from get-of-sire records.

2. Permanent grade for use in dam-produce comparisons in get-of-sire summaries should be based largely upon yearling and two-year-old grades, since growth and development at the age when most commercial cattle are marketed are of greatest practical significance.

3. Record the individual's weight and grade directly on this sheet at annual weighing and grading. Space is allowed for weaning data and for annual records up to seven years. Mature weights are recommended for use in the pedigree.

4. Head may be described as poor, fair, good, excellent, etc., and also by more

Beef Cattle Get of Sire Record

(Use separate sheets for males and females)

SIRE NAME U.C. Rare Prince No. 711

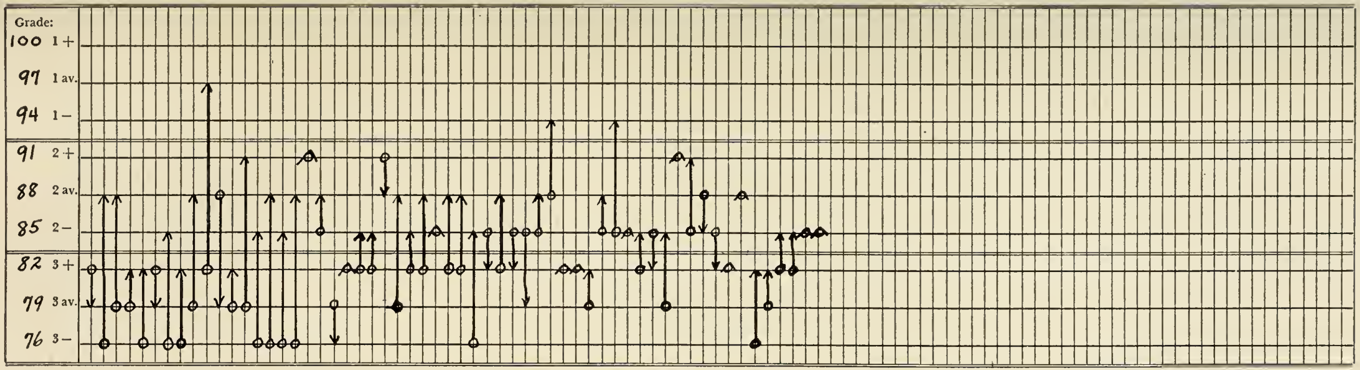
SEX OF GET Bulls

Herd No.	Date of Birth	Dam		Weaning Data				Yearling Data				Two-year-old Data				Head	# Color, Markings and Hair Coat	Remarks and Disposal
		No.	Grade	Date	Weight	Grade	Condition	Date	Weight	Grade	Condition	Date	Weight	Grade	Condition			
817	12/28/43	712	88	8/16/44	515	85	med.	5/18/45	920	85	good					Fair	M.L.R.; B.I.R. curly	up standing, flat ribbed, med. fleshing, late maturing
818	1/5/44	518	88	9/15/44	615	94	good	5/18/45	1025	94	good					Excel.	M.R.; B.I.B.R. short, glossy	very rugged, good bone, thick, well balanced. Slight slope in rump
824	3/10/44	763	88	11/15/44	590	88	good-									good	M.D.R. curly	good bone and scale, Low set, slightly long; moderate thick flesh
831	4/29/44	693	91	2/13/45	615	88	good									good	M.D.R.; B.I.R. short; S.N.; B.L.B.	good back and loin; lacks depth; rump slopes.
834	5/5/44	120	88	2/15/45	610	91	good									good	M.R. Short glossy	Thick fleshed, well balanced, smooth, good bone med. scale.
836	5/16/44	602	94	2/15/45	550	88	med.									good	M.R. Med. long, curly	good type, thick quarters. medium scale.
843	10/2/44	72	88	6/12/45	510	91	med.					(Mother had little milk)				good	M.R. Med. long, curly	Well muscled. Legs straight
846	10/26/44	134	91	6/12/45	535	88	med.					(Heifer's 1st calf)				good	M.R.; S.K. med. curly	Med. bone and scale, compact good loin and quarters.
849	10/30/44	716	91	6/12/45	540	91	good									good-	M.L.R. Short hair	Thick, well balanced, early maturing, small size.
781	7/25/42	618	91	3/15/43	460	91	med.	11/16/43	920	85	good					good-	M.L.R.	Failed to develop, lacks width & general ruggedness - small.
806	9/14/43	748	91	5/15/44	405	82	med.	(Poor type, lacks thickness, character; castrated)								poor	M.L.R.	Sold to butcher -
810	9/9/43	747	88	5/15/44	605	85	good	9/15/44	865	85						Fair	M.R. R.I.B.R.	Lacks depth and thickness, flat in craps and ribs.
814	10/28/43	521	94	6/14/44	475	85	med.					(Mother poor milker)				good	M.R.; B.I.B.R. curly	good as a calf but developed defect in hocks. Sold to butcher.
826	3/17/44	762	85	11/15/44	495	85	med.					(Castrated)				poor	M.R. curly	Upstanding, shallow, thin fleshed sold to butcher.
837	5/23/44	572	91	2/15/45	415	85	med.	5/14/45	675	82						poor	M.L.R. curly	Light bone and quarter, shallow; too small. Sold to butcher.
				# Code: M.L.R. = med. Light red														
				M.R. = med red														
				D.R. = dark red.														
				R.I.R. = red around right eye lids.														
				L.I.R. = " " left " "														
				B.I.B.R. = both eyes have some red on lids, but not continuous, ie. broken red.														
				L.B. = line back.														
				B.L.B. = broken line back or spot of white.														
				R.N. = red neck.														
				S.N. = "smutty" nose.														
Totals			1347		7035	1317												
Averages			88.8		* 541	87.8		*(2 steers omitted from average weight.)										

Fig. 10 (II). Get-of-sire record form, with an example of its use.

Graphic Get of Sire Summary

Circles show grade of dam; Arrowheads, the grade of produce. Animals number 901 to 192   1939, 1940 and 1941 calf crops. Grade cows



Grade of Sire 2+ (91) Calif. Experimenter No. 533

Average Grade of Dams 3+ (82)

Dam—Produce Comparisons

Superior to Dams No. 36 per cent 60

Equal to Dams No. 12 per cent 20

Inferior to Dams No. 12 per cent 20

Average weaning age—days, ~~males~~ steers 251 females 254

Average weaning weight—pounds, ~~males~~ steers 541 females 485

Average grade of get 85.3 = 2−

A better than average breeding bull that should make some improvement in many purebred herds.

COMPARISON BY GRADES

Grades	Dams Number	Dams Per Cent	Produce Number	Produce Per Cent
1+	0		0	
1 av.	0		1	1.7
1−	0		2	3.3
2+	3	5.0	4	6.7
2 av.	5	8.3	16	26.6
2−	14	23.3	16	26.6
3+	18	30.0	15	25.0
3 av.	10	16.7	5	8.3
3−	10	16.7	1	1.7

CHARACTERISTICS OF GET

Uniform in type; good heads.
The majority have thick rear quarters, good depth of muscling over the back and loin. Calves are better than average in weight for age. Steers were excellent feeders and finished rapidly.
All heifers grading 2− and over were saved for replacements.
Two inbred daughters were outstanding; one was inferior.
Only a few calves showed lack of width of back—the most conspicuous fault of the sire. Many were slightly prominent at the tail head.

Fig. 11 (II). The reverse side of the get-of-sire record form, showing use of the graphic arrow chart and a summary of data. The circles in the graphic summary represent the grade of the dams; the arrows, the grade of their calves. A glance at the chart reveals the uniformity or lack of it, and the approximate limit of improvement the sire is capable of making.

Beef Cattle Individual Life Record

NAME Topsy Premier 2nd HERD NO. 606
REG. NO. 2603805 HORN OR CHAIN NO. 606
DATE OF BIRTH 10/15/36 BRED BY Univ. of Calif PERMANENT GRADE: 1— (94)

SIRE

Premier Domino
Grade 1 (97) Wt. 1800-2000
Breeder Wm. Briggs, Dixon Calif. No. 1928354

- Dandy Domino 46th — Grade 1 (97) Wt. 1800-2000, Breeder Chas. Rule, No. 1573523
  - Dandy Domino 1090961 — Grade Wt.
  - Blue Belle 48th 1220411 — Grade Wt.
- Miss Dare 24th — Grade 1-(94) Wt. large cow, Breeder, No. 1538005
  - Colorado 6th — Grade Wt.
  - Miss Dare 20th 972534 — Grade Wt.

DAM

Calif. Topsy
Grade 1 (97) Wt. 1310-1470
Breeder Univ of Calif. No. 1852011

- Dandy Domino 46th — Grade 1 (97) Wt. 1800-2000, Breeder Chas. Rule, No. 1573523
  - Dandy Domino 1090961 — Grade Wt.
  - Blue Belle 48th 1220411 — Grade Wt.
- Calif Tulip — Grade 1 (97) Wt. 1250-1300, Breeder Univ of Calif., No. 1465223
  - Avon Gaston 1304001 — Grade 2+(91) Wt. 1700-1800
  - Calif Tessie 1190728 — Grade 1-(94) Wt. 1300+

Weight and Grade Record

Date	Age	Weight	Condition	Grade
6/5/37	8 mo	495	good	2+(91)
10/13/37	12 "	690	good	1-(94)
9/14/38	2 yrs.	970	good	1-(94)
6/13/40	4 yrs	1180	med.	1-(94)
6/16/42	6 yrs	1100	med	1-(94)
6/15/43	7 yrs	1120	med	
6/15/44	8 yrs	1220	good	

Head: good+ excellent breed and sex character
Disposition: quiet easily handled
Milking Ability: very good
Quality and Texture of Fleshing: smooth, moderately thick
Color, Markings and Hair Coat: med. red; red spot left eyelid smutty nose

Produce Record

Herd No.	Sex	Date of Birth	Sire	Name	Reg. No.	Weaning Data				Yearling Data				Head	Color, Marking and Hair Coat	Remarks and Disposal
						Date	Weight	Grade	Condition	Date	Weight	Grade	Condition			
677	C	2/14/39	604	Calif Rare Lady	2917112	11/6/39	525	94	excel.	2/10/40	590	94	good+	good	M.L.R Short glossy	Excel. type, smooth, thick. Extreme early maturing. Too small, sold —
711	B	3/29/40	604	U.C. Rare Prince	3099885	11/15/40	580	94	excel.	7/15/41	1015	94	excel.	excel.	M.L.R med. short	Excel. type, low set, deep, thick; heavy bone, slightly long body (re-tain)
747	C	5/22/41	WHR Reality	Reality Lass	3309577	1/16/42	466	88	good	9/15/42	800	88	good	good	M.R. Line back	good scale and type. lacks muscling over back. Retained in herd
777	C	5/1/42	Dom. Prince	Topsy Domino	3577573	1/15/43	500	91	good	9/15/43	785	91	good	good-	M.R; Bl.Be. long curly	Deep, thick, rugged. Tail head high slightly rough. Retained in herd.
801	C	5/13/43	Dom. Prince	Topsy Domino 2nd	3896228	1/16/44	515	97	excel.	9/15/44	875	94	excel	good+	M.R.; white spot on back; curly	Outstanding calf. Not so good as two-yr. old. Retained in herd.
838	C	5/23/44	711	Princess Topsy	4119985	2/15/45	500	88	good						M.L.R. med. curly	good type but somewhat narrow; ewe necked; arch in back. Retained.
868	B	4/17/45	680	U.C. Rover Dom. 8th												

Disposal:

Fig. 12 (II). Individual life record form giving the history of an excellent breeding cow having all grade-1 parents in the first two generations of the pedigree and having an excellent production record.

521 No.

Breeding Record

Breeding Dates and Bull Used					Calving Date	Gestation, Days	Remarks
10/4/35 Reality 20th					7/20/36	289	Calf died soon after birth
8/31/36 Reality 20th					6/19/37	292	Bull, later castrated
12/27/37 Reality 20th	1/18/37 Reality 20th				11/3/38	289	Heifer
3/16/39 Reality 20th	4/27/39 Reality 20th	7/17/39 Reality 20th	1/14/40 Reality 20th		10/20/40	279	Heifer calf (free-martin) born twin with a bull calf that was dead at birth.
1/22/41 Reality 20th					10/31/41	282	Bull calf, born dead
12/22/41 608					10/1/42	282	Heifer
11/22/42 711	12/16/42 711	1/16/43 711			10/28/43	285	Calf good when young but later developed bowed hocks, became lame and was sold to butcher. Bull.
1/7/44 779	4/20/44 711	6/23/44 418					Irregular heat, then developed chronic bulling. Sold to butcher.

Description of animal and other information on life history:

A deep-bodied, thick-fleshed cow with excellent bone and scale. Strong in back, but slightly flat in loin. Lacked some in fullness of heart and crops. Long rump and good quarters. Slightly cycle hocked.

Milked fairly well with first two calves, but later calves did not receive enough milk. Calves generally developed well after weaning and during 2nd year. Only one heifer retained in herd.

Fig. 13 (II). The reverse side of the individual life record form, filled out for a cow whose production was rather poor. Keeping complete reproduction records frequently reveals causes and suggests remedies for reproductive failure. Data of this kind when available for analysis may show deformities, stillbirths, and some abortions to be hereditary.

Breeding List and Reproduction Record

Cow Number	Name	Date of Calving	Breeding Dates and Bull Used				Date Due	Date of Calving	Herd No. and Sex of Calf	Remarks
716	Topsy Lass	3/10/43	1/1/44 779	1/25/44 781			10/30/44	10/30/44	849 B	Cow small, allowed to develop and bred for fall calving
773	U.C. Sister Domino	——	1/5/44 779	1/25/44 779	2/12/44 779	3/4/44 779				Bull 779 proved to be sterile. Sperm abnormal.
			3/24/44 711	Pasture bred to 680				2/10/45	——	aborted; hump-backed fetus with under-shot jaw
521	Topsy Premier	10/28/43	1/7/44 779	4/20/44 711	6/23/44 418					Irregular heat, then chronic bulling. Sold to butcher.
618	Countess Avalon 2nd	11/4/43	1/9/44 711				10/15/44	10/15/44	845 c	
123	Lorena Jr. Domino	3/20/44	5/18/44 680				2/25/44	3/10/45	857 B	Castrated, not registered
752	Tops' Lady	2/1/44	5/21/44 680				2/28/44	3/13/45	860 B	
107	Maybelle Domino	3/12/44	5/25/44 680	6/19/44 680	Pasture bred to 680			5/1/45	873 c	
693	Sister Real	4/29/44	6/5/44 680	Pasture bred to 680				4/7/45	866 c	
518	Calif Betty	1/5/44	6/11/44 711				3/22/45	3/25/45	864 c	
64	Lorena Adv. A Domino	4/7/44	6/13/44 680				3/25/45	4/30/45	872 B	
14	Marie Domino	5/9/44	6/15/44 680				3/27/45	4/5/45	865 B	
572	Princess Nora	3/23/44	6/21/44 680	Pasture bred to		680		4/23/45	871 c	
787	Miss Rover	——	7/18/44 680	Pasture bred to		680		5/3/45	875 c	

Fig. 14 (II). Breeding list and reproduction record valuable for planning and carrying out the breeding program for the season and for analyzing the yearly reproductive performance. Some of the difficulties often encountered are illustrated.

specific terms such as "too long," "narrow muzzle," "coarse, lacking femininity and character."

5. Wildness, nervousness, or similar undesirable traits should be recorded under "Disposition." Quiet disposition is essential to efficiency. Wild animals usually should be culled, since the tendency for transmission to offspring is strong and since one wild animal may make a whole herd difficult to handle.

6. Milking ability is reflected fairly well by weaning weights; but more reliable criteria are growth, fatness, and condition of hair of calves at 3 to 4 months, before they begin to forage extensively for themselves, coupled with observations of udder development of the cows. Field notes should be kept and transferred to individual records.

7. Records of color and markings will give information on the inheritance of such variations as line back in Herefords, and will give a better basis for decision to discard or to retain because of other more important considerations. The type, character, color, and quantity of the hair coat have a bearing on climatic adaptation; these were previously discussed.

8. Data for the produce record can be transferred from get-of-sire records. Other data, such as show-ring winnings, may be shown under "Remarks and Disposal."

9. The reverse side of form 2 provides space for the breeding record and for other information and notes on life history. Breeding data may be transferred from records on form 3 or similar "barn record." Some cattlemen may not care to transfer these data for each cow. To do so is considered desirable, however, in order to complete the whole picture for each animal on one sheet. By use of such records, strong evidence has come to light indicating that many losses such as stillbirths, premature dead calves, and other reproductive failures are hereditary in origin. The economic importance is so great that such data can and should receive serious attention in selective breeding. Data on actual length of gestation may also contribute useful information in these respects. Such records are also helpful in diagnosing some infectious causes of reproductive failure.

Form 3, Breeding List and Reproductive Record

In many cases, pocket-sized records will be more convenient. It is desirable, however, to transfer them to more permanent and less easily lost forms. The large form shown provides for the possible advance listing of the cows to be bred to each bull and for recording the date the last calf was dropped, breeding dates, due date, calving date, herd number, and sex of the calf resulting from the service indicated.

Generally this record would be kept at the barn or herdsman's quarters. As soon as a sheet is completed, the record may be filed in the office record book, and data transferred to individual cow records. The basic data from these records may be summarized diagrammatically as proposed by Mead (16) or according to modifications of this plan as used by Kingman (17) on the Wyoming Hereford Ranch. Such records are extremely valuable in directing efforts in proper channels for improved calf crops and in diagnosing some breeding troubles.

If consistently kept, these records should aid materially in herd analysis, in systematically proving bulls, and in breeding more largely upon the basis of progeny performance. Such records would be essential if, in the future, the breeders of purebred beef cattle see fit to use coöperatively the techniques now available for artificial insemination. A few outstanding proved bulls, each siring up to 500 calves yearly with artificial insemination, could provide large numbers of higher-grade range bulls for natural service. Such a procedure has enormous potentialities in improving the commercial beef-cattle population of the state.

The value of the records depends largely upon the knowledge, ability, and integrity of the individual operator and his continuous, unbiased study of the problems involved. The records do not represent a short cut to a cattle-breeding Utopia for the novice. They should, however, make the efforts of experienced cattlemen more effective and help the inexperienced to get on the right track more rapidly.

Systematic Identification. All major beef-breed associations require tattooing of the ears for permanent individual identification. Individual breeders usually develop their own system. For small herds, numbering the animals serially as they are born is a simple procedure; and commonly, one can repeat the series without duplication by the time numbers reach 999, thus avoiding more than three figures. The Aberdeen Angus Association requires herd number in one ear and an assigned herd, or breeder, identification mark in the other. The University herd, for example, is assigned the mark "UCF."

For progeny performance and breeding records of all kinds, convenient field identification that will give as much information as possible without becoming too complicated and conducive to error is essential. This information can include year of birth, sire, herd number, and the number of the dam. To avoid errors, the field identification number should coincide with the tattoo number.

A good system with horned animals is to tattoo serially in one ear and in the other designate the sire by letter or number, along with the year of birth. For example, left ear, 232; right ear, A5 or 1–5, indicating sire A or 1 and 1945 as the year of birth. At about two years of age, these numbers can be branded on the horns for field identification. When men on horseback are working the cattle in pastures, horns branded both on the front and back prove helpful.

Linn (18) has described an excellent system of marking, particularly useful in artificial insemination when cows are brought into a breeding plant. This consists of tattooing the serial number in one ear; the dam number and sire number in the other. An example is as follows: right ear, herd number 521; left ear, $\frac{25}{420C}$, indicating that cow no. 420 is the dam, C her third calf, and 25 the number of the sire. Linn also recommends giving the herd number on the front of one horn and on the top rear of the other. Later, if rebranding is necessary, it can be done on the front and rear of the opposite horns.

Field identification of polled animals is more of a problem. Neck chains and "cold-iron" branding are two possibilities. Suggestions for branding serially with caustic fluid are given in Section IV. With short-haired cattle, these brands may be permanently legible; but with longer- or curly-haired animals, clipping the brands twice yearly is necessary to facilitate field identification. Unless the number brand is placed upon the loin, it must be registered, along with the ownership brand, with the Bureau of Livestock Identification, California State Department of Agriculture.

Selective Breeding of Commercial Cattle

Figure 15 (II) shows steers about 12 months old, representative of the 1 to 3 grades outlined in the chart, table 5 (II). There is no sharp line of demarcation between grades, and borderline cases often make the decision difficult. The contrast within the range of one whole grade, however, is readily discerned from the photographs. All these animals were relatively smooth and trim. They varied mostly in shortness and sturdiness of legs and in depth, thickness, and development of hindquarters, loin, and back. Many defects not shown by these illustrations could result in placing an animal in the lower grades.

The data on 886 calves sired by 18 dif-

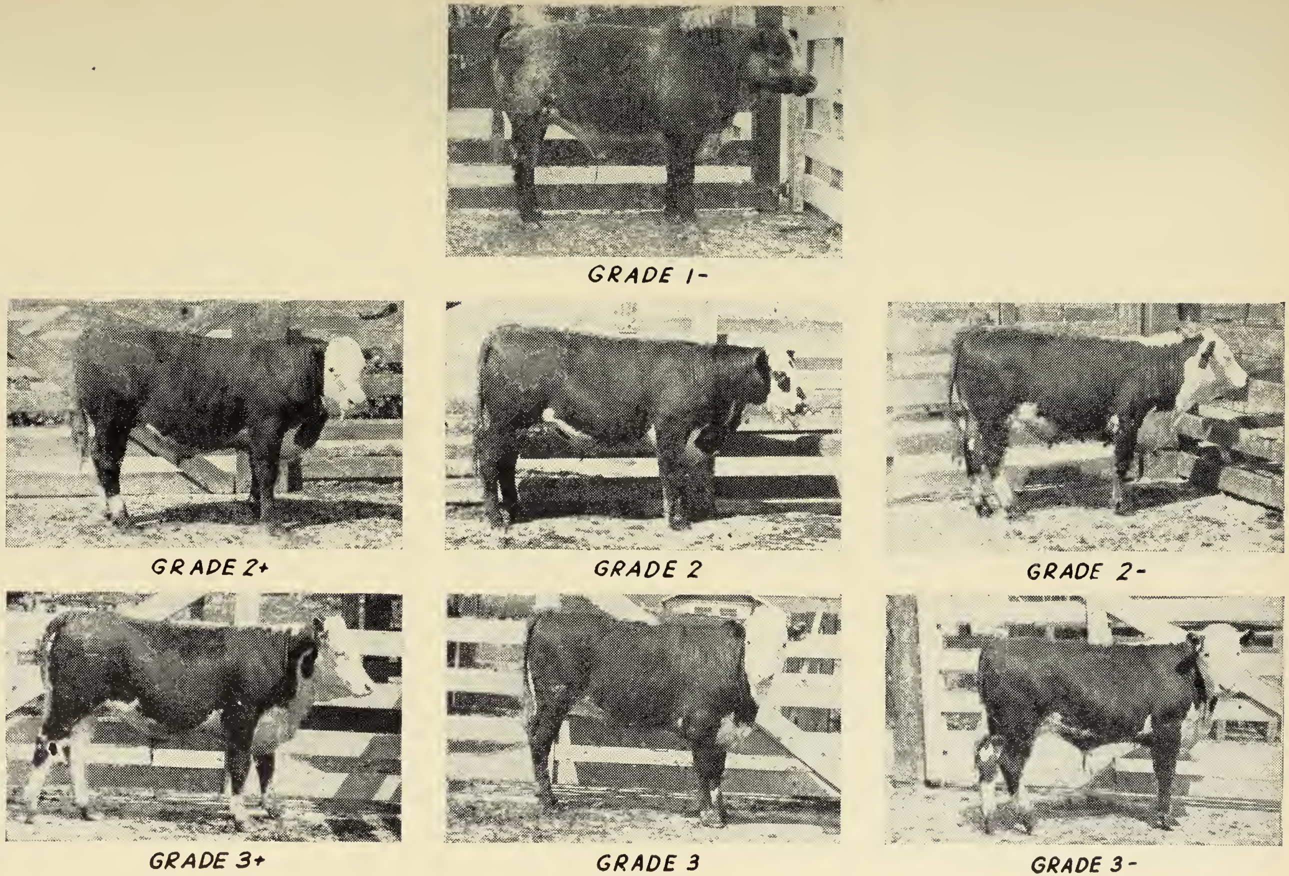


Fig. 15 (II). Steers, representing grades 1– to 3– described in table 5 (II). The steer at the top, an Aberdeen Angus × Shorthorn crossbred from the University purebred herd, is somewhat younger than the other steers. The grade 2+, 2, and 2– steers are from the second cross of University bulls on grade cows. The grade 3+, 3, and 3– steers are from the first cross on original cows in coöperators' herds. Note the decrease in depth, thickness, fleshing quality, and size of bone from higher to lower grades. Many low-grade animals are rough and have other defects of conformation not shown by these examples.

ferent bulls from the University herd used in commercial herds of several coöperating cattlemen and in the San Joaquin Experimental Range herd may be tabulated as follows:

Average grade of bulls	88.8
Average grade of all cows	77.6
Average grade of all calves	82.0
Percentage of calves in:	
Grade 1	0.34
Grade 2	41.87
Grade 3	49.20
Grade 4	8.57

If the average grade of the bulls is added to the average of the cows, and the sum is divided by 2, the result is not far from the observed average of the calves. Thus, the well-known genetic principle that offspring tend toward an intermediate between the parents is demonstrated.

As is also well known, improvement is slower as approach is made to the grade of the bulls—more accurately, to the average of their ancestors in the first few generations. This fact is illustrated below.

	Average grade
239 cows	72.3
239 calves	79.3
Improvement, 7.0 grade points or 0.78 of a grade	
886 cows	77.6
886 calves	82.0
Improvement, 4.4 grade points or 0.49 of a grade	
189 cows	82.2
189 calves	84.9
Improvement, 2.7 grade points or 0.30 of a grade	

Figure 16 (II) gives a visual idea of the progress made by using grade-2 bulls on range cows. These bulls came from a herd where constructive breeding has been practiced for years; their near ancestors were all as good as the individual bulls, or better. The cow herd was culled regularly, and replacements were selected.

Figure 17 (II) is a uniform group of low-set, thick-bodied, early-maturing "good doing" calves, representing the second generation of selective breeding that started with grade-3 cows. These calves averaged 83 grade points, or good to choice. The sire graded 1–(94), and his parents and grandparents all were grade 1. These are fairly typical of second-generation selective breeding. In 1943 the calves in another coöperator's herd, for example, ran 47 per cent choice, 53 per cent good (mostly at the top of the grade); the average of all was 83.6 grade points.

The first cross of these bulls on medium (grade 4) cows resulted in 82 per cent grade-3 (or better) calves and 18 per cent in the top end of grade 4.

Another genetic rule is that when both parents vary at either extreme (good or bad) from the average of the breed, the offspring will generally be nearer the average than the parents. Extremely tall parents, for example, usually have offspring shorter than themselves but taller than average. Naturally, therefore, some poor individuals breed better than they appear, and most of the offspring from grade-1 beef cattle are themselves grade 2.

These generally recognized genetic laws confirm the statements made in the grading chart. Grade-2 commercial cattle, with few exceptions, have reached a practical top, for this grade range is the approximate average of present-day purebreds, and to go farther means competing with breeders for outstanding herd sires. Continuous use of the best range bulls available, with strict culling of cows and careful selection of replacement heifers, is necessary to maintain the present average quality until the average of the purebreds is further improved. Grade-3 bulls can rarely make much improvement except on very plain cattle.

Selection of Bulls. The data presented above emphasize the desirability of selecting higher-grade bulls having the characteristics and adaptations set forth in "Production Factors in Beef-Type Selection." Too, these bulls have a greater chance of breeding true if their ancestors in the first two or three generations were *all* as good as or better than the individuals in question. Selection for ability to

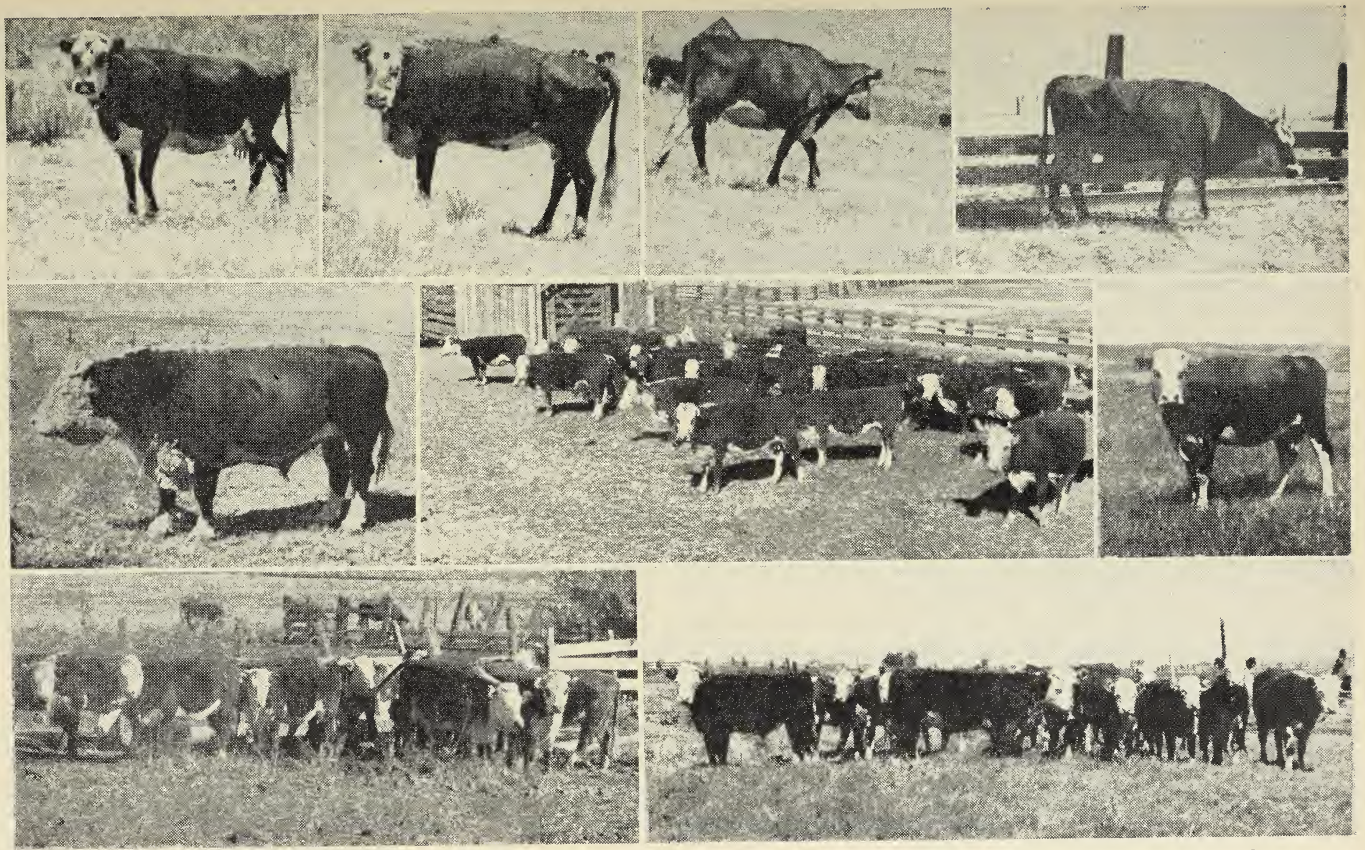


Fig. 16 (II). Herd improvement through selective breeding and culling. The top row shows representatives of the original grade-4 cows in a coöperator's herd. The University bull shown in the middle row was mated to the selected heifers on his right, which were out of the original cows and by good Hereford bulls, to produce the "good to choice" replacement heifers and feeder steers shown in the lower row. This bull, 10 years old when the picture was taken, had bred 50 to 60 cows yearly for several years. The herd contains nearly 100 uniform type breeding cows by this bull. The sire used on these second-generation replacement heifers transmitted uniformly good milk production—a very important factor in production of heavy calves.

sire milk production in the daughters, as previously outlined, should be considered when possible. Since steers are intermediate in size between bulls and females, bulls should have more weight for age than steers, more bone and ruggedness if size is to be maintained. They should have good head with obvious masculinity, besides desirable body conformation.

Four- to eight-year-old proved bulls have repeatedly demonstrated ability to sire 50 to 60 calves a year under good pasture conditions and with reasonable off-season care. Such a bull at an initial price of $750 results in no more yearly bull cost per calf than a $250 bull siring 20 calves yearly on the range—a higher-than-average number. This is one way to make good bulls go farther, to justify the higher cost, and to have all the difference in calf value as profit.

Selection should be made from well-fed bulls that have had a chance to develop. Underfeeding may not only change an animal's form, but may also prevent the owner from determining potential ability to make rapid gain.

Closely bred bulls having the type, ruggedness, and other characteristics stressed, more often breed uniformly true to type than those with a great mixture of lines of breeding. When desirable blood lines have been proved, the breeder should continue them and select consistently the same type of bulls, in order to secure uniformity in the herd.

Purebred bulls that have been raised on cultivated pasture or in other close confinement are in no condition for range service. They should be purchased in time to become acclimated and adjusted to new feed. Usually they need to exercise and toughen their muscle, not merely to reduce their fat. Bulls should be well fed and in good active condition when put in service.

Selection and Culling of Cows. Usually in California, improvement in feed and other environmental conditions and better management are necessary if the benefits possible through selective breeding are to be realized. Under extremely rigorous conditions, the plainer, slower-developing animals may actually do better than those bred for rapid growth and early development.

The manner in which the animal grows determines largely its shape and size and the proportion of meat to bone and fat. A splendidly bred beef animal that has experienced alternate stages of good gains and severe losses in weight will appear

Fig. 17 (II). A group of "good to choice" weaner calves representing second generation from University bred sires starting with grade-3 cows. The sire graded 1–, and his parents and grandparents were all in grade 1.

Fig. 18 (II). Yearling heifers from selected cows and top bulls for herd replacement. They were wintered on 13 pounds of mixed hay and $1\frac{3}{4}$ pounds of grain per head daily. Their daily gain during the winter was 0.96 pound.

entirely different from one of equal breeding that has made continuous growth from calfhood. Since different parts of the body do not develop at the same rate, alterations of conformation may depend on the age when development was restricted. "Running out" or becoming "fine-boned" is a common expression for some of these effects. The remedy is more logically applied through supplementing or otherwise improving the feed supply than through buying big-boned, rough bulls. A realization of the manner in which animals grow and react to environment can bring purebred breeders and commercial cattlemen closer in a mutual understanding of their respective problems.

Poor feed means low calf crop and a high percentage of dry cows. If buyers are allowed to pick out the good individuals, if there is automatic culling of all dry cows, if undeveloped heifers are bred, and if *all* heifer calves are required for replacement, then the cow herd may "run down" faster than improvement can be made by good bulls. Although feed supply and disease are the main factors influencing calf crops, some nonbreeders continue to occur in all herds regardless of feed conditions. If feed is adequate, then dry cows usually should be sold. Nonbreeders may result from hereditary abnormalities, infections, and injuries in calving. All poor milkers should be culled. Under inadequate feed conditions most of the dry cows customarily sold are pregnant and would drop calves in a few months, while many cows with calves at side may be the ones due to miss or be late in calving the following year. The practice of culling dry cows under these conditions usually does not lead either to increased calf crop or to herd improvement, for many of the best cows are sold and poorer ones are retained in the herd.

The most rapid progress is through breeding enough of the best cows to the best bulls to supply the heifers necessary for replacement. Such heifers give greater assurance of breeding true. The results of this procedure are shown in figures 16, 17, and 18 (II). Weaning time is ideal for selection and culling. One should keep deep-bodied, naturally thick-fleshed cows with good heads, that have raised good calves and still maintain thrifty condition. All long-headed, thin-necked, shallow-bodied, flat-ribbed, "dippy"-loined, light-hindquartered kinds and old cows should be culled. The grading chart can serve as a guide and as a

means of more clearly defining objectives in selection and culling. A herd of quiet, easily handled cattle is a distinct advantage; selection for these qualities and a culling of the wild cows should be practiced. Often one may best handle the culled cows by placing them in a separate pasture to prevent breeding and thus save bull costs. Calves from culled cows may be vealed or kept until weaning time. Calves are commonly vealed in order to sell fat cows. Frequently it may be profitable to raise the calves to weaning even though the cows are sold cheaper as feeders or low-grade slaughter animals. If held for another season, cull cows consume feed that can be utilized better by more efficient animals. A systematic program of breeding, culling, and feeding as outlined will revolutionize in a few years the quality of an ordinary herd. The effect of selective breeding and culling in herds representing the three principal beef breeds is shown in figures 19, 20, and 21A and 21B (II).

Longevity is important, and to keep proved breeding cows as long as they are productive is frequently desirable. At the University Farm, under protected conditions, occasional cows have regularly produced calves until fifteen to twenty years of age.

Specific data on individual Angus cows are as follows:

1 cow produced 12 calves in 15 years

1 cow produced 12 calves in 16 years

2 cows each produced 14 calves in 17 years

1 cow produced 15 calves in 17 years

1 cow produced 15 calves in 19 years

1 cow produced 16 calves in 20 years

On the San Joaquin Experimental Range, efficient culling has done much to improve the herd. The more complete records kept there have revealed interesting data. The breeding history of two original cows, nos. 12 and 28, purchased in 1935 appears at the top of page 43.

These two cows and their offspring, in a herd free from infectious abortion, show a disastrous reproductive history that gives some evidence of being inherited. Both hereditary and environmental factors may be involved. To obtain data on a situation of this kind, one must have carefully kept records.

The history of two other original cows, nos. 19 and 45, maintained under identical conditions in the supplementally fed A herd, appears at the bottom of page 43.

Of these cows, no. 19 graded 2– or low choice; no. 45, 3+ or high good. The increased value of the latter animal is readily seen in the notably greater weight and higher grade of her calves at weaning time—probably the result of increased milk production. The average difference in the calf weaning weights was 152 pounds. No. 45, with 8 heavier calves, produced a lifetime total of 1,595 pounds more calf weight at weaning than no. 19 with seven light calves. The extra value of such consistently heavier weights would at least pay for the year-long maintenance of the dam. No. 19, not giving so much milk, was always in better flesh, graded higher, and might have been looked upon as a better "doer."

Another pair of original cows, nos. 15 and 36, maintained in the B herd (not fed supplements) present the following reproduction data:

Year	No. 15	No. 36
1935	Calved	Calved
1936	Calved	Dry
1937	Calved	Calved
1938	Calved	Dry
1939	Calved	Calved
1940	Calved	Dry
1941	Calved	Calved
1942	Culled for age	Culled for age

There has been much discussion regarding cows that breed only in alternate years. These data are evidence that such animals exist. As soon as recognized, perhaps, they should be culled. On the other hand, no. 36, an average-sized cow, might have produced a calf each year under bet-

Cow No. 12
- 1935, calved, heifer no. 125
  - 1938, no. 125 calved heifer no. 827, both culled
- 1936, aborted
- 1937, premature—died
- 1938, calved, heifer no. 818 culled
  - 1941, no. 818 calved heifer no. 160; 1944, no. 160 aborted
  - 1942, no. 818 calved bull no. 227, died of bloat
  - 1943, no. 818 calved bull no. 317, sold
  - 1944, no. 818, calf born dead

Cow No. 28
- 1935, calved heifer no. 133
  - 1938, no. 133, calf born dead
  - 1939, no. 133 calved heifer no. 907
    - 1942, no. 907, calf born dead
    - 1943, no. 907, calf born dead
    - 1944, no. 907 calved bull no. 428
  - 1940, no. 133 dry
  - 1941, no. 133 aborted, culled
- 1936, aborted
- 1937, calved bull no. 717, sold
- 1938, dry
- 1939, calved bull no. 939, sold culled

ter nutrition; but she did not do so under conditions that still made it possible for no. 15 to calve annually. No. 15 was a small cow that never weighed over 875 pounds before calving. She recovered parturition and lactation loss, returning to about this weight each year. Record keeping that permits observations of this kind is not difficult if a system once becomes established and if equipment, particularly scales, is available. The most difficult problem is practical and convenient individual identification. At the San Joaquin Experimental Range all cattle are tattooed with a serial number in the ear and with a corresponding number branded on the hip with caustic branding fluid. By being clipped twice yearly, the brands are kept legible for easy field identification. With proper equipment and quiet, well-managed cattle, this procedure should also be practical in many commercial herds. The year of birth may be indicated in the serial number by the initial number; for example, 1945 calves could be marked 501, 502, and so on.

Cow No. 19

Year	Calved	Weaning age, in days	Weaning weight, in pounds	Grade
1935	Heifer 127	237	330	Good (3)
1936	Bull 220	260	400	Medium (4)
1937	Heifer 703	260	390	Low good (3–)
1938	Bull 804	248	410	Low good (3–)
1939	Heifer 957	267	400	Good (3)
1940	Heifer 045	233	425	High good (3+)
1941 (Dry)	...	...	...	....
1942	Heifer 280	217	327	Low choice (2–)
Culled for age	...	...	...	

Cow No. 45

Year	Calved	Weaning age, in days	Weaning weight, in pounds	Grade
1935	Bull 104	241	465	Choice (2)
1936	Heifer 225	256	530	High good (3+)
1937	Heifer 709	246	560	Choice (2)
1938	Bull 809	246	545	High good (3+)
1939	Heifer 959	266	585	Choice (2)
1940	Bull 041	259	600	Choice (2)
1941	Heifer 124	235	511	Low choice (2–)
1942	Bull 275	258	481	Low choice (2–)
Culled for age	...	...	...	....

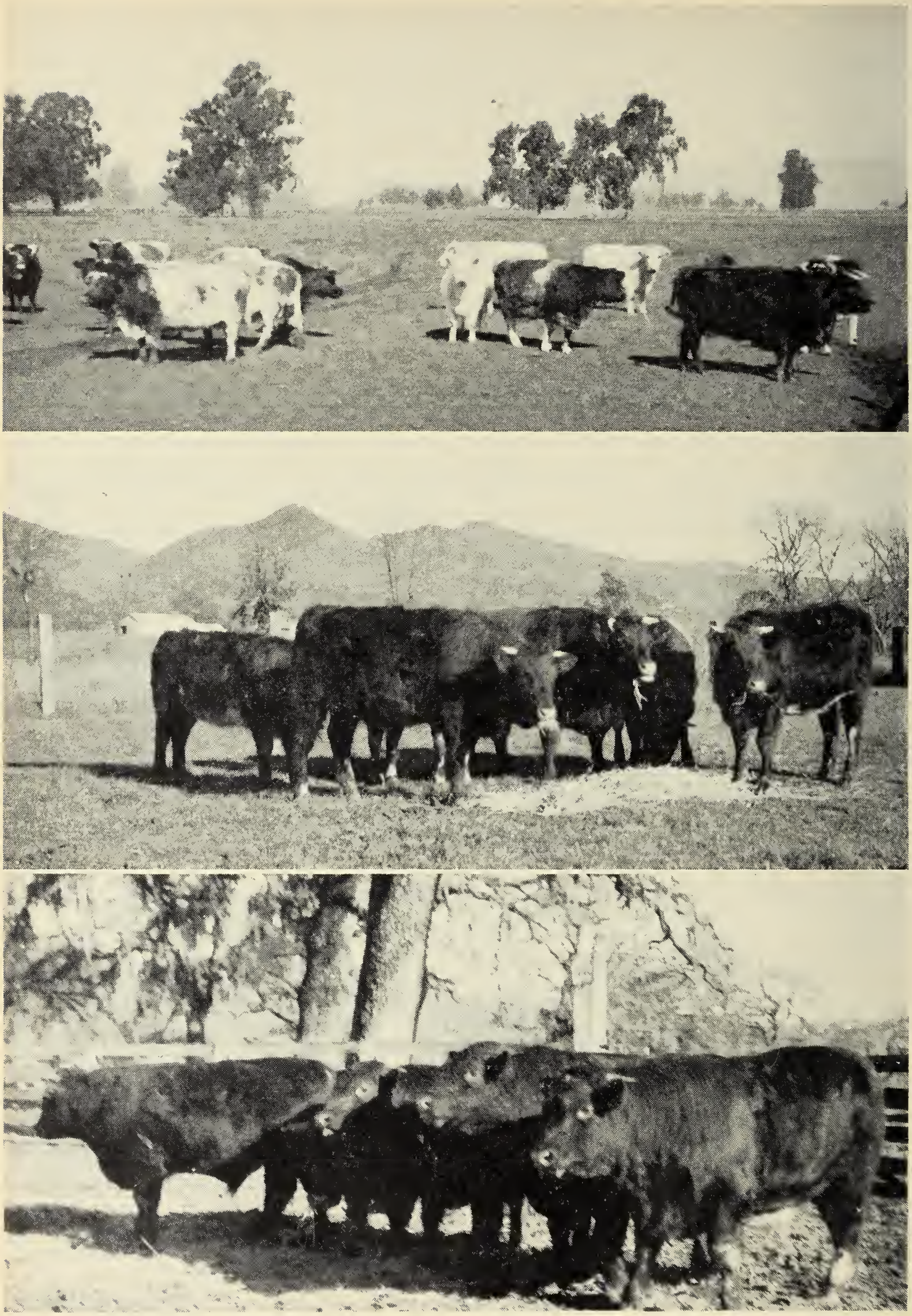


Fig. 19 (II). Shorthorns of the type shown in each of the pictures above make excellent foundation animals for the production of high-quality feeder cattle which will attain heavy weight for age if good management practices are followed.

Fig. 20 (II). Individual performance records are kept on these very desirable Aberdeen Angus females. Never pampered, they have been fed only for normal growth. Their depth and thickness are due to natural fleshing. In the upper picture the cow on the right is the dam of the two heifers. The average daily gain from birth has been 1.8 pounds for the 17-month-old heifer on the left; 2.2 pounds for the 6-month-old calf in the center. The seven heifers in the lower picture range from 14 to 17 months of age. Their average daily gain from birth has been 1.5 pounds.

Crossbreeding

The benefits of crossbreeding fall into two general categories: first, increasing general thrift, vigor, and rate of gain through hybrid vigor (heterosis); second, securing better adaptation, conformation, and performance by combining the desirable characteristics of different breeds. Special features of breeds and types that may be combined through crossing are, for example, the polled condition and the tendency for marbled flesh of Aberdeen Angus, the milking ability of Shorthorns, the adaptation to range and the "rustling" ability of Herefords, and the heat resistance of Brahmans.

A crossbred, by definition, is the progeny that results from the mating of different breeds. In the past, casual methods of alternating the breeds of bulls used on a miscellaneous assortment of breeding cows have sometimes been employed. The systematic breeding and culling programs that have produced high-grade uniform herds of Hereford, Shorthorn, or Aberdeen Angus represent definite progress. A commercial producer having a low-grade herd of cows can advance faster if he first improves his cattle by a succession of good, uniform-type, purebred bulls of similar breeding. After the herd becomes uniform and further improvement is slow or uncertain, systematic crossbreeding may then be employed to advantage.

Fig. 21A (II). What type is best? That is a question of paramount interest among breeders and producers. The upper row shows foundation cows of the University of California Aberdeen Angus herd. The middle row shows two descendants (steer calves) that were Champion and Reserve Champion Angus at the International, Chicago, in 1919 and 1921, respectively. The lower row shows 5 descendants: 3 purebred and 2 crossbred (including the Grand Champion heifer, Lula Mayflower) comprising the best group of 5 at the International in 1921. These cows are medium beef type, with more scale, bone, body length, and leg length than have recently been popular. They were feminine, a little lean of neck, sturdy, long-lived, excellent milkers, and great producers. The steers which they produced were the straight, trim, smoothly fleshed kind with reasonable length in relation to depth that recent carcass tests have shown to give high carcass yield and cut-out value at the moderate degree of finish which is economical to produce and has widest consumer popularity.

According to estimates, 60 to 70 per cent of market swine and an equally large percentage of range sheep are crossbreds, or from types or strains that originated from crossbreeding. Practical difficulties in herd segregation and management have prevented extensive use of crossbreeding in beef cattle. Commercial production of swine is based largely upon purebred foundations; that of cattle, upon grades whose ancestry frequently shows a mixture of breeding. In some areas one breed predominates to an extent where ranchers cannot well obtain good bulls of another breed locally. Bulls of a second breed are sometimes less well adapted to the environment than are those of the leading breed in the area.

Often the advantage of crossbreeding is a combination of hybrid vigor and special adaptations. The hybrid vigor to be expected would be the same, for example, whether Shorthorn bulls were used on Hereford cows or the reverse. Generally, however, better results up to weaning age might be expected when Hereford bulls are used on Shorthorn cows, whose greater average milk production would favor the potentially greater growth rate of their crossbred calves. Table 9 (II) presents selected data from a crossbreeding experiment conducted at the Miles City (Montana) Experiment Station. The complete report is available in circular form (19). The data in table 9 (II) show higher weaning weights for the crossbreds, particularly in the second cross involving three breeds and when these three-breed-cross heifers were backcrossed to the Hereford. Similarly, rate of feed-lot gain was consistently greater for the crossbreds, and generally they produced higher yield and carcass grade. Efficiency of feed utilization did not appear significantly different between purebred and crossbred cattle. Calf crop percentages, as a whole, were higher for crossbreds than for purebreds. The authors point out that certain superior

Fig. 21B (II). These Herefords are the result of selective breeding. The cow at the top provides ample milk for the calf, yet remains in good condition herself. The bull (center) is a proven sire. For five years he was mated with 60 to 70 of the top cows in the herd, and replacement heifers, such as are shown in the lower picture, were selected from this breeding. When seven years old, this bull sired 62 calves under meadow pasture conditions. The cow herd is largely composed of his descendants.

TABLE 9 (II)

Comparison of Hereford, Hereford × Shorthorn (first cross); Hereford, Hereford × Shorthorn × Angus (second cross); and Hereford, Hereford × Shorthorn × Angus × Hereford (third cross) Steers

	Hereford	Hereford × Shorthorn	Hereford	Hereford × Shorthorn × Angus	Hereford	Hereford × Shorthorn × Angus × Hereford
	Purebred	First cross	Purebred	Second cross	Purebred	Third cross
Number of steers	38	34	46	18	98	16
Birth weight, pounds	79.1	84.8	79.2	79.1	82.8	88.3
Weaning age, days	180.3	174.7	174.7	176.1	177.4	179.6
Weaning weight, pounds	402.6	416.8	386.2	440.9	402.4	502.6
Average daily feed lot gain, pounds	1.81	2.08	1.79	1.93	2.28	2.41
Gain per 100 pounds T.D.N.	18.30	18.49	18.17	17.20	18.76	17.49
Dressing per cent	56.3	57.7	58.0	59.8	58.9	58.7
Average slaughter grade	Average good	Average good	Average good	Low choice	Low choice	Average choice

Source of Data:
Knapp, B. Jr., A. L. Baker, and R. T. Clark. Crossbred cattle for the northern Great Plains. U.S.D.A. Cir. 810:1–5. 1949.

performing lines of purebred Herefords (not used in the crossing experiments) made more rapid gain and were more efficient than the crossbreds.

Similarly, crossbred steers in the University of California herd, full-fed from weaning, have averaged heavier than the purebreds, at least up to 12 months of age. There was only a slight indication, however, that the crossbreds involving all the breeds gained more rapidly than the straight Shorthorns, which were the heaviest of the purebreds. Data from the first four calf crops in a crossbreeding experiment with Aberdeen Angus and Herefords at the Ohio Experiment Station have not shown any consistent or conspicuous advantages of the crossbreds.

The cross of Aberdeen Angus bulls on females of strong Shorthorn breeding has generally been rated high because the offspring were hornless and reasonably uniform in color (black or blue gray), and because most Shorthorn cows make excellent mothers. The superior fleshing quality of the Aberdeen Angus usually shows up in this cross.

The crossing of Brahman cattle with temperate-zone beef breeds is to obtain climatic adaptation and resistance to external parasites and tick-borne diseases. Hybrid vigor is also obtained. Experience indicates that the ¼ to ½ Brahman (generally ⅜ Brahman) carries enough heat resistance to withstand the hotter areas in the United States. The effort generally has been to use the minimum Brahman blood to attain climatic adaptation and the maximum of Shorthorn, Hereford, or Aberdeen Angus blood for superior beef conformation and early maturity.

Contrary to the general idea that all crossbreds should be marketed, extensive experiments and experience with swine and common practice with sheep show that the crossbred dam may have a distinct advantage. The swine experiments have shown that crossing the crossbred dam with a sire of a third breed gives added hybrid vigor and that the dam is a superior mother. Apparently, from the cattle experiment mentioned above the three-breed cross and systematic rotation of sires of the three breeds, starting on a purebred or genetically equivalent grade foundation herd of one breed, may prove highly desirable. The herd segregation

necessary to do the job right appears rather complicated for most beef-cattle setups.

To be successful, crossbreeding must be based upon a good foundation herd and upon consistent use of superior sires, along with a selection and culling of females. Indiscriminate crossbreeding is as likely to combine all the poor qualities of the parents as all the good ones.

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J. Earl Coke, Director, California Agricultural Extension Service.

5m-4,'52(A339)M.H.

NUTRIENT REQUIREMENTS AND CATTLE FEEDS

Nutrient Requirements
Symptoms of Nutritional Deficiencies
Important Toxic Trace Elements
Characteristics of Range Forage
Harvested Roughages, Grains, and By-products
Preparation of Feeds
Economical Feeds

Nutrient Requirements

The National Research Council* in 1945 issued a report, *Recommended Nutrient Allowances for Beef Cattle* (rev. 1950). Table 10 (Sec. III) from this report gives the expected gains for different ages, sexes, and production objectives; also the necessary daily intake of total dry feed equivalent, digestible nutrients, digestible protein, calcium, phosphorus, and carotene. Table 11 (III) presents the same data expressed as percentage in the ration or amount per pound of feed. These tables of requirements and their use, in conjunction with tables 12, 13, 14 (III), on the composition of feeds, are discussed in sections IV and V.

* Much of the material in the following paragraphs and in "Symptoms of Nutritional Deficiencies," is adapted from the National Research Council publication: Guilbert, H. R., Paul Gerlaugh, and L. L. Madsen. Recommended nutrient allowances for beef cattle. A report of the Committee on Animal Nutrition of the National Research Council. 32 p. Washington, D.C. 1945. (Rev. 1951.) In many passages, the wording is unchanged from the original text.

Manual 2, a revision of Circular 131, replaces Extension Circular 115, *Beef Production in California*, by H. R. Guilbert and L. H. Rochford. Some tables and other data from the original circular are used in the manual.

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Mr. Hart is Professor of Veterinary Science and Veterinarian in the Experiment Station.

Requirements for nutrients other than those listed in tables 10 and 11 (III) are briefly discussed in the text which follows.

Vitamins. Under usual conditions of management, beef cattle receive enough vitamin D from exposure to direct sunlight or from sun-cured roughages. The requirement for young calves is reported to be about 300 international units per 100 pounds of live weight per day. Vitamin D is essential to calcium and phosphorus utilization and to the prevention of rickets and other bone abnormalities.

The water-soluble vitamins thiamin, riboflavin, niacin, pyridoxine, pantothenic acid, and biotin, and the fat-soluble vitamin K are synthesized by microorganisms in the rumen. So far as is known, a dietary supply of these vitamins is not essential after cattle are 2 months of age and rumen function has been established, provided the ration is otherwise adequate. Possibly with gross deficiencies of protein or other nutrients in the diet, conditions in the rumen may not permit the microörganisms to produce optimum quantities of these essential vitamins. Further research is needed to show definitely what bearing this problem may have upon practical beef production.

The need of vitamin E in the diet of cattle has not been demonstrated, nor is

there evidence of rumen synthesis of this vitamin, which is widely distributed in feeds. Claims made for beneficial results of vitamin-E therapy in reproduction in cattle have not been substantiated up to this time.

TABLE 10 (III)

RECOMMENDED DAILY NUTRIENT ALLOWANCES FOR BEEF CATTLE

(Based on air-dry feed containing 90 per cent dry matter)

Body weight, pounds	Expected daily gain, pounds	Daily allowances per animal						
		Total feed		Digestible protein, pounds	Total digestible nutrients, pounds	Calcium, grams	Phos-phorus, grams	Caro-tene,* milligrams
		Per cent of live weight	Per animal, pounds					
Normal growth, heifers and steers								
400	1.6	3.0	12	0.9	7.0	20	15	24
600	1.4	2.7	16	0.9	8.5	18	15	36
800	1.2	2.4	19	0.9	9.5	16	15	48
1,000	1.0	2.1	21	0.9	10.5	15	15	60
Bulls, growth and maintenance (moderate activity)								
600	2.3	2.7	16	1.3†	10.0	24	18	36
800	1.7	2.1	17	1.4	11.0	23	18	48
1,000	1.6	2.0	20	1.4	12.0	22	18	60
1,200	1.4	1.8	22	1.4	13.0	21	18	72
1,400	1.0	1.7	24	1.4	14.0	20	18	84
1,600	...	1.6	26	1.4	14.0	18	18	96
1,800	...	1.4	26	1.4	14.0	18	18	108
Wintering weanling calves								
400	1.0	2.8	11	0.7	6.0	16	12	24
500	1.0	2.6	13	0.8	7.0	16	12	30
600	1.0	2.5	15	0.8	8.0	16	12	36
Wintering yearling cattle								
600	1.0	2.7	16	0.8	8.0	16	12	36
700	1.0	2.4	17	0.8	8.5	16	12	42
800	0.7	2.3	18	0.8	9.0	16	12	48
900	0.5	2.0	18	0.8	9.0	16	12	54
Wintering pregnant heifers (Weights are for beginning of winter period; gains are average for period)								
700	1.5	2.9	20	0.9	10.0	18	16	42
800	1.3	2.3	20	0.9	10.0	18	16	48
900	0.8	2.0	18	0.8	9.0	16	15	54
1,000	0.5	1.8	18	0.8	9.0	16	15	60

* The recommended carotene allowances for fattening animals are at the same rate as for cattle in other classifications. This is about the minimum rate that will result in significant storage, and thus assure contribution of vitamin-A value for human use from the beef liver and fat. For optimum growth or feed-lot gains and freedom from clinical symptoms, 1.5 mg. carotene for each 100 pounds body weight suffices for cattle previously depleted of body stores. This level may be used except for pregnant or lactating cows when economically necessary. The vitamin-A value of the liver and the body fat of animals so fed, however, would be practically nil. Actually no dietary carotene or vitamin A is needed so long as the animals have sufficient storage reserve to meet physiological needs.

† During periods of moderate to heavy service, a level of about 2.0 pounds of digestible protein is tentatively suggested.

TABLE 10 (III)—*Continued*

Body weight, pounds	Expected daily gain, pounds	Daily allowances per animal						
		Total feed		Digestible protein, pounds	Total digestible nutrients, pounds	Calcium, grams	Phosphorus, grams	Carotene,* milligrams
		Per cent of live weight	Per animal, pounds					
Wintering mature pregnant cows (Weights are for beginning of winter period; gains are average for period)								
800	1.5	2.8	22	1.0	11.0	22	18	48
900	1.0	2.2	20	0.9	10.0	18	16	54
1,000	0.4	1.8	18	0.9	9.0	16	15	60
1,100	0.2	1.6	18	0.8	9.0	16	15	66
1,200	0.0	1.5	18	0.8	9.0	16	15	72
Cows nursing calves, first 3 to 4 months after parturition								
900–1,100	None	...	28	1.4	14.0	30	24	300
Fattening calves finished as short yearlings								
400	Average	3.0	12	1.1	8.0	20	15	24
500	for	2.8	14	1.2	9.5	20	16	30
600	period	2.7	16	1.3	11.0	20	17	36
700	2.0 pounds	2.6	18	1.4	12.0	20	18	42
800	daily	2.5	20	1.5	13.5	20	18	48
900		2.3	21	1.5	14.5	20	18	54
Fattening yearling cattle								
600	Average	3.0	18	1.3	11.5	20	17	36
700	for	3.0	21	1.4	13.5	20	18	42
800	period	2.8	22	1.5	14.0	20	19	48
900	2.2 pounds	2.7	24	1.6	15.5	20	20	54
1,000	daily	2.6	26	1.7	17.0	20	20	60
1,100		2.4	27	1.7	17.5	20	20	66
Fattening two-year-old cattle								
800	Average	3.0	24	1.5	15.0	20	18	48
900	for	2.9	26	1.6	16.0	20	20	54
1,000	period	2.7	27	1.7	17.0	20	20	60
1,100	2.4 pounds	2.6	29	1.8	18.0	20	20	66
1,200	daily	2.4	29	1.8	18.0	20	20	72

Minerals Other than Calcium and Phosphorus. Besides calcium and phosphorus, cattle require magnesium, sulfur, potassium, sodium, chlorine, iodine, manganese, iron, copper, and cobalt. Information is presented on elements for which deficiency symptoms are known, or for which need of supplementation in a localized area has been demonstrated.

Common Salt. Salt supplies sodium and chlorine. The physiological requirements appear to be very low, about 1.5 grams daily of sodium and less than 5 grams daily of chlorine being sufficient for growth. Larger amounts (11 grams sodium and 15 grams chlorine for a cow producing 2 gallons of milk daily) are required for lactation. Since, however,

salt is also used as a condiment, voluntary intake is much above these apparent physiological requirements. Consumption depends upon the amount in the feed, as well as upon other conditions, but varies usually between 1.0 and 2.5 pounds per month. Cattle should have free access to salt.

Iodine. The use of salt containing 0.015 to 0.020 per cent potassium iodide

TABLE 11 (III)

RECOMMENDED DAILY NUTRIENT CONTENT OF RATIONS FOR BEEF CATTLE
(Based on air-dry feed containing 90 per cent dry matter)

Body weight, pounds	Expected daily gain, pounds	Daily feed		Allowance as per cent of ration or amount per pound of feed				
		Per cent of live weight	Per animal, pounds	Digestible protein, per cent	Total digestible nutrient, per cent	Calcium, per cent	Phosphorus, per cent	Carotene,* milligrams per pound
Normal growth, heifers and steers								
400	1.6	3.0	12	7.5	58	0.37	0.28	2.0
600	1.4	2.7	16	5.6	53	0.25	0.21	2.2
800	1.2	2.4	19	4.7	50	0.19	0.17	2.5
1,000	1.0	2.1	21	4.3	50	0.16	0.16	2.8
Bulls, growth and maintenance (moderate activity)								
600	2.3	2.7	16	8.1†	63	0.33	0.25	2.2
800	1.7	2.1	17	7.8	65	0.28	0.22	2.7
1,000	1.6	2.0	20	6.4	60	0.22	0.18	2.7
1,200	1.4	1.8	22	6.0	59	0.19	0.17	3.0
1,400	1.0	1.7	24	5.4	58	0.17	0.15	3.2
1,600	...	1.6	26	5.4	54	0.15	0.15	3.7
1,800	...	1.4	26	5.4	54	0.15	0.15	4.2
Wintering weanling calves								
400	1.0	2.8	11	6.4	55	0.32	0.24	2.2
500	1.0	2.6	13	6.2	54	0.27	0.20	2.3
600	1.0	2.5	15	5.3	53	0.24	0.18	2.4
Wintering yearling cattle								
600	1.0	2.7	16	5.0	50	0.22	0.17	2.2
700	1.0	2.4	17	4.7	50	0.21	0.16	2.5
800	0.7	2.3	18	4.5	50	0.20	0.15	2.7
900	0.5	2.0	18	4.5	50	0.20	0.15	3.0
Wintering pregnant heifers (Weights are for beginning of winter period; gains are average for period)								
700	1.5	2.9	20	4.5	50	0.20	0.18	2.1
800	1.3	2.3	20	4.5	50	0.20	0.18	2.4
900	0.8	2.0	18	4.5	50	0.20	0.18	3.0
1,000	0.5	1.8	18	4.5	50	0.20	0.18	3.3

* The minimum level of carotene for optimum growth and fattening and freedom from clinical symptoms is one fourth of the amounts listed for various classes and weights. This level allows no margin of safety and permits no storage, but may be employed for growth and fattening when economically necessary. The allowances listed are adequate for reproduction with only a small margin of safety and very small storage in the new-born calf (see footnote, table 10, III).

† During periods of moderate to heavy service, a digestible-protein level of 7.5 to 8.0 per cent is tentatively suggested.

has effectively prevented goiter in iodine-deficient areas. Griem and his associates (1) have recommended, as sufficient, iodized salt containing 0.01 per cent iodine, stabilized to prevent loss. Without stabilization, iodine is rapidly lost from salt blocks in the field; to insure further against loss, one should protect salt boxes from direct sunlight and from rain.

An economical and effective way to supply cattle with iodine is to purchase the potassium iodide and mix it with salt as needed. One ounce of potassium iodide to 300 pounds of fine-ground salt gives a mixture containing about 0.02 per cent. The potassium iodide should be finely ground, mixed thoroughly with a little salt, and then mixed with the remainder

TABLE 11 (III)—*Continued*

Body weight, pounds	Expected daily gain, pounds	Daily feed		Allowance as per cent of ration or amount per pound of feed				
		Per cent of live weight	Per animal, pounds	Digestible protein, per cent	Total digestible nutrient, per cent	Calcium, per cent	Phosphorus, per cent	Carotene,* milligrams per pound
Wintering mature pregnant cows (Weights are for beginning of winter period; gains are average for period)								
800	1.5	2.8	22	4.5	50	0.20	0.18	2.2
900	1.0	2.2	20	4.5	50	0.20	0.18	2.7
1,000	0.4	1.8	18	4.5	50	0.20	0.18	3.3
1,100	0.2	1.6	18	4.5	50	0.20	0.18	3.7
1,200	0.0	1.5	18	4.5	50	0.20	0.18	4.0
Cows nursing calves, first 3 to 4 months after parturition								
900–1,100	None	...	28	5.0	50	0.24	0.18	11.0
Fattening calves finished as short yearlings								
400	Average	3.0	12	9.2	67	0.37	0.28	2.0
500	for	2.8	14	8.6	68	0.31	0.25	2.1
600	period	2.7	16	8.1	68	0.28	0.23	2.2
700	2.0 pounds	2.6	18	7.8	68	0.25	0.22	2.3
800	daily	2.5	20	7.5	68	0.22	0.20	2.4
900		2.3	21	7.2	68	0.21	0.19	2.6
Fattening yearling cattle								
600	Average	3.0	18	7.2	65	0.25	0.21	2.0
700	for	3.0	21	7.0	65	0.21	0.19	2.0
800	period	2.8	22	6.8	65	0.20	0.19	2.2
900	2.2 pounds	2.7	24	6.7	65	0.18	0.18	2.2
1,000	daily	2.6	26	6.5	65	0.17	0.17	2.3
1,100		2.4	27	6.3	65	0.16	0.16	2.4
Fattening two-year-old cattle								
800	Average	3.0	24	6.3	62	0.18	0.18	2.0
900	for	2.9	26	6.3	62	0.17	0.17	2.1
1,000	period	2.7	27	6.3	62	0.16	0.16	2.2
1,100	2.4 pounds	2.6	29	6.3	62	0.15	0.15	2.3
1,200	daily	2.4	29	6.3	62	0.15	0.15	2.5

TABLE 12 (III)

COMPOSITION OF FEEDS

Feeds	Dry matter, per cent	Total digestible nutrients, per cent	Digestible protein, per cent	Calcium		Phosphorus		Carotene, milligrams per pound	Approximate relative productive value, per cent (barley = 100)
				Per cent	Grams per pound	Per cent	Grams per pound		
Air-dry forages:									
Alfalfa hay, average	92.8	50.4	10.8	1.51	6.85	0.21	0.95	19.4	53
Alfalfa hay, very leafy*	90.0	53.7	12.4	1.69	7.68	0.24	1.09	....	57
Asparagus butts, dried	91.0	47.1	9.7	....	....	....	....	....	47
Barley hay*	85.0	50.0	4.4	0.17	0.77	0.25	1.13	....	49
Barley straw	89.5	44.0	1.0	0.09	0.41	0.06	0.27	0.14	29
Bean straw, field*	90.0	45.0	3.0	1.67	7.54	0.13	0.59	....	27
Bean straw, lima	90.0	48.0	6.0	....	....	....	....	....	46
Beet tops	80.0	47.5	7.7	0.45	2.08	0.19	0.86	....	48
Flax hulls	90.0	34.7	0.8	....	....	....	....	——	35
Cottonseed hulls	91.3	35.7	0.5	0.14	0.64	0.05	0.23	——	38
Oat hay, moderately green	88.2	48.1	3.3	0.27	1.22	0.22	1.00	8.00	46
Oat straw	91.9	45.5	1.5	0.23	1.04	0.13	0.59	0.14	29
Sudan grass hay, before bloom	90.0	50.0	6.7	0.47	2.13	0.24	1.09	2.9	48
Vetch and oat hay, half vetch	90.0	50.0	7.0	0.55	2.50	0.26	1.20	....	53
Winery pomace	89.3	30.7	1.9	....	....	....	....	....	35
Wild oat hay	92.5	48.7	3.6	0.22	1.00	0.25	1.13	....	43
Range forages:									
Annual grasses, mostly soft chess, seed stage, nearly mature	90.0	46.0	——	0.35	1.59	0.20	0.91	....	..
Annual grasses, soft chess and fescue, mature dry	90.0	39.5	——	0.30	1.36	0.20	0.91	——	..
Bur-clover, green, seed stage	90.0	56.2	11.8	0.86	3.90	0.31	1.40	....	..
Bur-clover, seed stage, dry, leached by 0.3 inch of rain	90.0	50.8	10.6	0.89	4.00	0.30	1.36	——	..
Bur-clover, seed stage, dry, leached by 0.8 inch of rain	90.0	48.5	10.3	0.93	4.20	0.29	1.32	——	..
Broad-leaf filaree, mature dry	90.0	43.3	——	1.70	7.70	0.13	0.59	——	..
Broad-leaf and red-stemmed filaree, mixed, mature, dry, leached	90.0	37.0	——	2.3	10.40	0.10	0.45	——	..
Broad-leaf filaree-grass mixture as grazed by cattle	90.0	40.0	0.0–2.0	....	....	....	....	——	..
Silages, roots, and tubers:									
Alfalfa silage, slightly wilted	31.1	18.8	4.0	0.38	1.72	0.06	0.27	14.9	18
Carrots	12.0	9.6	0.8	0.06	0.27	0.06	0.27	10.5	11
Corn silage, well matured, average	29.1	19.0	1.0	0.08	0.36	0.08	0.36	4.0	24
Mangels	9.2	6.6	0.7	0.02	0.09	0.02	0.09	....	9
Potatoes	21.1	17.0	0.7	0.01	0.05	0.06	0.27	——	22
Potatoes, dried	90.0	72.6	3.0	0.04	0.18	0.26	1.16	——	93
Sorghum silage, sweet	25.3	16.1	0.7	0.09	0.41	0.04	0.18	....	18
Sugar beets	20.6	17.3	1.0	0.03	0.13	0.04	0.18	——	23

Dotted lines (....) indicate lack of data; solid lines (——) insignificant amounts or none present.

Sources of data:

Data for feeds marked with an asterisk (*) are taken from: Morrison, F. B. Feeds and feeding. 1050 p. 20th ed. The Morrison Publishing Company, Ithaca, N. Y. 1936.

Other data are from: The U. S. D. A. Yearbook, 1939; California Agricultural Experiment Station; and: Guilbert, H. R., Paul Gerlaugh, L. L. Madsen. Recommended nutrient allowances for beef cattle. A report of the Committee on Animal Nutrition of the National Research Council. 32 p. Washington, D. C. 1945.

TABLE 12 (III)—*Continued*

Feeds	Dry matter, per cent	Total digestible nutrients, per cent	Digestible protein, per cent	Calcium		Phosphorus		Carotene, milligrams per pound	Approximate relative productive value, per cent (barley = 100)
				Per cent	Grams per pound	Per cent	Grams per pound		
Concentrates:									
Apple pomace, dried*	89.4	60.5	1.7	0.10	0.45	0.09	0.41	....	78
Babassu meal	92.7	79.7	21.3	....	....	....	....	....	101
Barley, California feed	90.0	78.0	7.8	0.05	0.23	0.39	1.77	—	100
Beans, recleaned*	90.9	64.8	13.4	0.14	0.64	0.45	2.05	—	81
Beet pulp, molasses, dried	92.0	74.0	7.7	0.59	2.68	0.09	0.41	—	94
Beet pulp, wet	12.3	9.4	1.1	0.09	0.41	0.01	0.05	—	..
Brewers' grains, dried, from California barley*	91.1	61.3	16.2	0.16	0.73	0.47	2.13	—	78
Brewers' grains, wet*	23.9	16.6	4.6	0.07	0.32	0.12	0.55	—	..
Coconut oil meal, old process	92.7	83.8	17.5	0.28	1.27	0.58	2.63	—	103
Corn, dent, No. 2	85.0	80.0	7.0	0.01	0.05	0.25	1.14	2.2	103
Cottonseed, whole*	92.7	91.0	17.0	....	....	0.55	2.50	—	115
Cottonseed meal, cold pressed (28 per cent protein)	93.5	70.8	23.4	0.17	0.77	0.64	2.90	—	90
Cottonseed meal (43 per cent protein)*	93.5	75.5	35.0	0.24	1.10	1.11	5.00	—	96
Cottonseed meal (41 per cent protein)	92.8	73.6	33.9	0.20	0.91	1.19	5.40	—	94
Distillers' corn grain, dried	93.2	81.6	20.1	0.04	0.18	0.29	1.32	....	108
Distillery slop, whole*	6.2	4.9	1.2	0.07	0.32	0.23	1.04	—	..
Figs, dried	....	69.0	4.0	....	....	....	....	....	87
Fish meal, over 63 per cent protein*	92.5	71.3	54.0	4.24	19.20	3.06	13.90	—	91
Hominy feed	90.5	88.3	8.2	0.03	0.14	0.44	2.00	—	110
Kafir	88.1	79.7	9.0	0.01	0.05	0.25	1.13	—	102
Linseed meal, Pacific Coast (28 to 30 per cent protein)	90.0	77.2	25.0	0.34	1.54	0.92	4.17	—	99
Milo	90.7	80.0	8.3	0.04	0.18	0.25	1.13	—	102
Milo heads, ground	89.6	76.0	8.1	0.08	0.36	0.24	1.09	—	97
Molasses, cane	76.0	57.0	0.9	0.35	1.59	0.06	0.27	—	73
Oats, Pacific Coast	90.0	72.0	7.6	0.09	0.41	0.33	1.50	—	92
Peanut oil meal (38 to 43 per cent protein)	93.6	78.8	37.0	0.10	0.45	0.50	2.27	—	101
Rice bran	91.2	67.5	8.3	0.10	0.45	1.84	8.35	—	87
Rice polish	90.0	81.0	8.2	0.03	0.14	1.54	6.89	—	104
Rye	90.5	79.6	9.3	0.04	0.18	0.37	1.68	—	102
Soybean oil meal	92.2	80.5	37.5	0.29	1.32	0.67	3.04	—	103
Wheat, Pacific Coast	90.0	84.0	9.3	0.03	0.14	0.43	1.95	—	108
Wheat bran	90.6	70.0	13.1	0.10	0.45	0.14	5.17	—	90

of the salt. The freshly prepared mixture should be supplied at frequent intervals in covered salt boxes.

Magnesium. Magnesium deficiency may result from prolonged feeding of calves on milk without grain or hay. Under these conditions, blood magnesium is lowered, and the animals usually die in tetany. When natural feed is the source, calves require about 0.6 gram of magnesium daily per 100 lbs. of body weight.

Cobalt and Copper. Deficiency of these elements has been demonstrated in different parts of the world, including the United States.

Cobalt deficiency has not been demonstrated in California nor has uncomplicated copper deficiency. Less than 5 parts per million of copper in the dry matter of pastures causes loss of appetite, bleaching of coat color, anemia, and, in many cases, diarrhea. Ataxia and stiffness of

pasterns in calves sometimes occurs. Over 7 parts per million of copper appear adequate when excess molybdenum or other unknown factors do not complicate copper utilization. The symptoms arising from excess molybdenum in California resemble those of copper deficiency, and copper therapy is being successfully employed to counteract molybdenum.

Cobalt requirement appears to be met by about 0.1 part per million in the dry matter of pasture, or about 0.1 milligram daily per 100 pounds of body weight. Less than these amounts has led to progressive emaciation, and, finally, to anemia.

The probability of copper deficiency being involved in hair bleaching sometimes observed in the granite area of the Sierra foothills, including the San Joaquin Experimental Range, has not been fully explored. Limited data show low or borderline copper content in dried forage which may be complicated by lower amounts of molybdenum than are generally considered toxic. Supplemental feeding of cottonseed cake prevented hair bleaching in the San Joaquin Experimental Range. Occasional occurrence of an ataxic nervous disorder in calves has been noted. Severe scouring, emaciation, and extreme demineralization of bones of cattle and sheep on peat-land clover pasture, although complicated by heavy parasite infestation, appear similar to "peat scours" described in New Zealand and involved with copper deficiency. These indefinite observations are reported here because more general recognition of the problem in the field helps to direct research attention to the affected areas.

Symptoms of Nutritional Deficiencies

Symptoms of nutritional deficiencies most often encountered in California are summarized in the following paragraphs. In some cases the symptoms are specific. Reduced appetite or growth, rough hair coat, and general unthriftiness are common to most states of undernutrition. Since deficiencies may range from very mild cases to severe, they may exist without causing gross symptoms. The more insidious, mild, and often multiple deficiencies, resulting in suboptimum performance rather than dramatic symptoms, are most difficult to diagnose, but are commonly the source of greatest economic loss.

TABLE 13 (III)

ESTIMATED CAROTENE CONTENT OF FEEDS IN RELATION TO APPEARANCE AND METHODS OF CONSERVATION

Feedstuff	Carotene, milligrams per pound
Fresh green legumes and grasses, immature	15–40
Dehydrated alfalfa meal, fresh, dehydrated without field curing, very bright green color	110–135
Dehydrated alfalfa meal after considerable time in storage, bright green color	50–70
Alfalfa leaf meal. bright green color	60–80
Legume hays, including alfalfa, very quickly cured with minimum sun exposure; bright green color, leafy	35–40
Legume hays, including alfalfa, good green color, leafy	18–27
Legume hays, including alfalfa, partly bleached, moderate amount of green color	9–14
Legume hays, including alfalfa, badly bleached or discolored, traces of green color	4–8
Nonlegume hays, including timothy, cereal, and prairie hays, well cured, good green color	9–14
Nonlegume hays, average quality, bleached, some green color	4–8
Legume silage	5–20
Corn and sorghum silages, medium to good green color	2–10
Grains, mill feeds, protein concentrates, and by-product concentrates, except yellow corn and its by-products	0.01–0.2

TABLE 14 (III)

Composition of Calcium and Phosphorus Supplements

Mineral supplement	Calcium		Phosphorus		Fluorine, per cent
	Per cent	Grams per pound	Per cent	Grams per pound	
Bone meal, raw, feeding	22.7	103	10.1	46	0.030
Bone meal, special steamed	28.7	130	13.9	63	.....
Bone meal, steamed	30.0	136	13.9	63	0.037
Defluorinated phosphate rock a*	21.0	95	9.0	41	0.15 or less
Defluorinated phosphate rock b*	29.0	132	13.0	59	0.15 or less
Defluorinated superphosphate	28.3	128	12.3	56	0.15 or less
Dicalcium phosphate	26.5	120	20.5	93	0.05
Disodium phosphate	nil	nil	8.6	39	....
Limestone	38.3	174	nil	nil	....
Monocalcium phosphate	16.0	72	24.0	109	0.05
Monosodium phosphate	nil	nil	22.4	102	....
Oyster-shell flour	36.9	167	nil	nil	....
Spent bone black	22.0	100	13.1	59	....

* Because of the limited number of products on the market, figures are given for two types of defluorinated rock that are being produced for livestock feeding.

Energy Intake (Total Digestible Nutrients). Lack of sufficient feed is probably the most common deficiency in beef cattle. In limited feeding during the winter, on overstocked ranges, or during the early green-feed period, low energy intake may be the sole deficiency. The results are slowing or cessation of growth (including skeletal growth), loss of weight, reproduction failure, and increased death loss. On ranges and pastures, low food intake commonly results in increased mortality from toxic plants and from lowered resistance to parasites and diseases. Very commonly, however, underfeeding is complicated by concomitant shortage of protein and other nutrients. (See fig. 26, IV.)

Protein. Shortage of protein is the second most common deficiency in beef cattle. These nitrogenous compounds are the principal building materials for muscle tissue, vital organs, hide, horns, and hair. Feeds low in them are nonlegume roughage, common grains, and mature range forage. Protein deficiency results in poor growth, depressed appetite, failure of milk secretion and of heat periods. If the deficiency is severe, not only does growth stop, but the muscle tissues are too depleted to supply vital organs, and the result is rapid weight loss, weakness, and emaciation (fig. 22, III).

Salt (Sodium Chloride). Salt deficiency is manifested by intense craving for salt, lack of appetite, and unthrifty appearance. Increased salt consumption may also result from depraved appetite caused by other deficiencies.

Phosphorus. Areas of phosphorus deficiency are widespread throughout the world, particularly in semiarid regions, and are commonly associated with phosphorus-deficient soils. As a rule, phosphorus content decreases markedly when plants fully mature and seeds shatter; and this deficiency, along with that of protein, commonly occurs when cattle must subsist for long periods on mature, nonleguminous dried grasses and herbs.

The earliest symptoms of phosphorus deficiency are decrease in blood phosphorus, in appetite, and in rate of gain. Milk production falls off. Efficiency of feed utilization, particularly of protein, is depressed. These effects are followed by depraved appetite with specific craving for bones, but may be manifested by chewing of wood, eating of dirt, and increased consumption of salt. Long-continued privation results in bone changes, lameness and stiffness of joints.

and even fracture of bones. Figure 23 (III) illustrates some effects of phosphorus deficiency.

Calcium. In contrast to phosphorus, calcium deficiency in beef cattle is comparatively rare and mild; the symptoms are inconspicuous. When fattening calves are heavily fed on concentrates with limited quantities of nonlegume roughage, their calcium intake is insufficient for optimum gain and bone development. Dried range forage, if predominantly grasses, may contain less than required minimum quantities; and cereal straws are usually deficient. Severe deficiency, which seldom occurs, may so deplete the bones of calcium and phosphorus that fractures result.

Iodine. The deficiency is usually manifested by the production of dead or nonviable goitrous calves. Occasional borderline cases may survive; in these the moderate thyroid enlargement that shows as a swelling at the throat disappears in a few weeks. Areas in which the iodine content of feed and water is deficient are localized. The whole lava country of northeast California is considered a borderline goiter area, with certain sharply defined localities definitely deficient in iodine. Even within these areas, there appears to be seasonal variation in occurrence of goiter. Some areas in the heavy-rainfall district of the north-coast section are also deficient. In such areas, losses of calves occur unless iodine is supplied. Thin, small calves from cows in good condition may possibly be a manifestation of mild deficiency even though enlarged glands are not observed.

Vitamin A. The natural source of vitamin A for cattle is carotene, a yellow pigment found in all green plant tissues. This is the yellow coloring matter of carrots, of milk, and of body fat of cattle. Carotene may be changed in the animal body to practically colorless vitamin A. In cattle most of the storage accumulating under favorable conditions is found in the liver as the preformed vitamin. Significant amounts of unchanged carotene are stored, particularly in the body fat.

Carotene decomposes rapidly under exposure to sun and air. Consequently, dry-range forage, bleached hays, and straw are lacking in this essential substance or

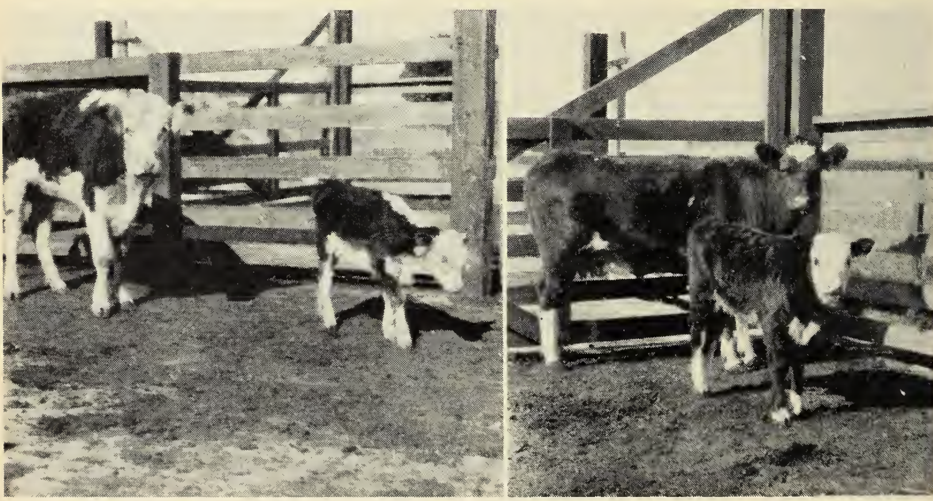

Fig. 22 (III). The cow on the left received a ration low in protein and phosphorus, similar in composition to that of dry grass filaree range forage. She was thin and weak, and produced little milk for her undersized calf. The cow on the right received the same ration plus 2 pounds daily of cottonseed meal. She maintained thrifty condition and produced abundant milk and a "growthy" calf. (From Ext. Cir. 115.)

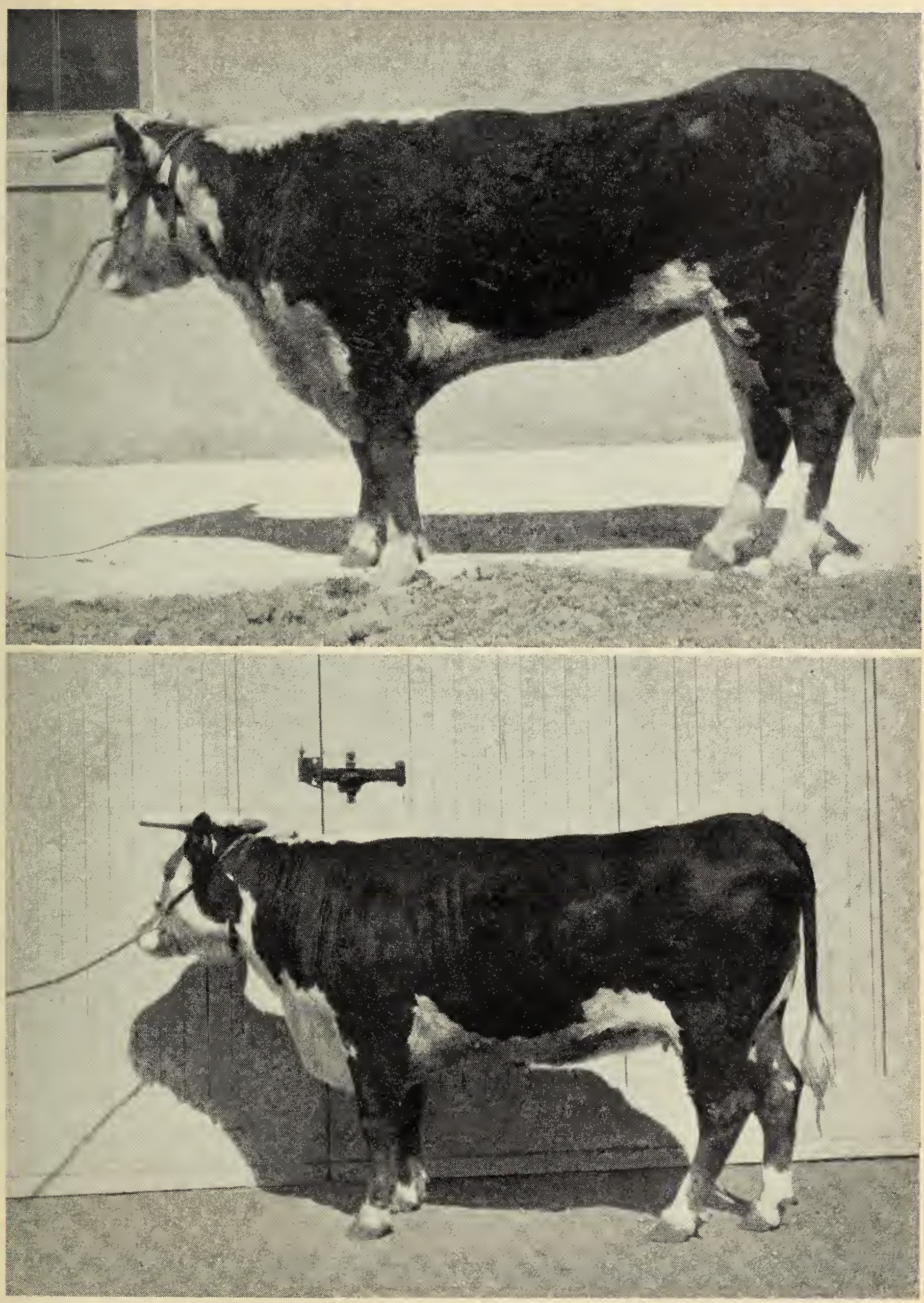

Fig. 23 (III). The heifer in the upper picture gained for a 6-month period on a ration containing 0.13 per cent phosphorus. She maintained weight for a year on 0.09 per cent phosphorus, but lost weight during 6 months when the ration contained only 0.07 per cent. Her appetite became poor and depraved, her blood phosphorus low; she had no heat period for more than a year. The control animal shown below received ample phosphorus supplement. She continued to gain, was thrifty, and had regular heat periods. The photographs were taken at the close of the experiment. (From Ext. Cir. 115.)

contain only traces of it. Since grains and other concentrate feeds, except yellow corn, are deficient in carotene, cattle must either have some green feed in the ration or draw upon reserves stored in the liver and fat tissues. If the period on deficient feeds is prolonged, reserves are depleted, and deficiency symptoms develop.

The first easily detected clinical symptom of vitamin-A deficiency is night blindness, readily observed when animals are driven about in twilight, moonlight, or other dim illumination. The trouble may be present even though the animals appear thrifty and are gaining at practically normal rates. When gross night blindness is evident, vitamin A in the blood is very low and liver reserves approach exhaustion. The next conspicuous symptoms usually developed are muscular incoördination, staggering gait, and convulsive seizures caused by a rise of the cerebrospinal fluid pressure, which also results in swelling and congestion around the entrance of the optic nerve into the eye. Total and permanent blindness in young animals results from constriction of the bony canals, and the pressure causes atrophy of the optic nerves. The eyes of affected cattle water profusely, wetting the cheeks. In advanced deficiency, nasal discharges are common. Unless death in convulsion or from intercurrent disease, such as pulmonary infection, intervenes, the corneas of the eyes become clouded and may, if subjected to infection, become ulcerated. Severe diarrhea in young calves and intermittent diarrhea at advanced stages of deficiency in adults are characteristic. In fattening cattle generalized swelling, referred to as anasarca, may occur.

Deficiency in bulls causes degeneration of the testicular germinal epithelium, production of defective sperm, and, finally, loss of sexual interest. Recovery of sexual desire promptly follows vitamin-A supplement, but several months may be required before the sperm becomes entirely normal.

Deficiency in the pregnant animal results in abortion or, at term, in birth of weak or dead calves (fig. 24, III).

Important Toxic Trace Elements

Fluorine. Minute quantities of fluorine are apparently needed to maintain the teeth. This chemical element is one of the halogen group to which iodine belongs. Although widely distributed in soils, waters, and in both animal and plant tissues, it is not found in abundant quantity. Dental enamel is relatively rich in the substance and contains 100 to 200 micrograms per 100 grams of dry substance. Fluorine is also found in much smaller amounts in bones, skin, blood, and hair.

In 1931 Smith, Lantz, and Smith, in the University of Arizona, College of Agriculture, proved that mottled enamel of the teeth in children was due to the presence of fluorine in drinking water at the very slight concentration of 3 to 7 parts per million. Incidence of mottled teeth among the Pima Indians resident in Sacaton, Arizona, was 100 per cent; and the drinking water was found to contain 3.9 parts per million (3.9 milligrams of fluorine per liter of water).

Toxic quantities of this substance from natural sources may be ingested by livestock over long periods if the drinking water contains much fluorine or if rock phosphate or mineral mixtures containing it are supplied. Phillips, Hart, and Bohstedt (2) show that an intake of 336 milligrams of fluorine per kilogram of body weight has proved toxic, as indicated by bone changes, molar teeth abrasion, and, in the last year of the experiment, noticeable failure in general health. Ingestion of the usual minute amounts must be continued over months to a year or more before noticeable symptoms appear. The teeth changes in cattle are in the molars, which become badly worn, with very irregular grinding surfaces. The enamel is dull, and the teeth become so sensitive that the animals tend to lap cold drinking water, but proceed to drink nor-

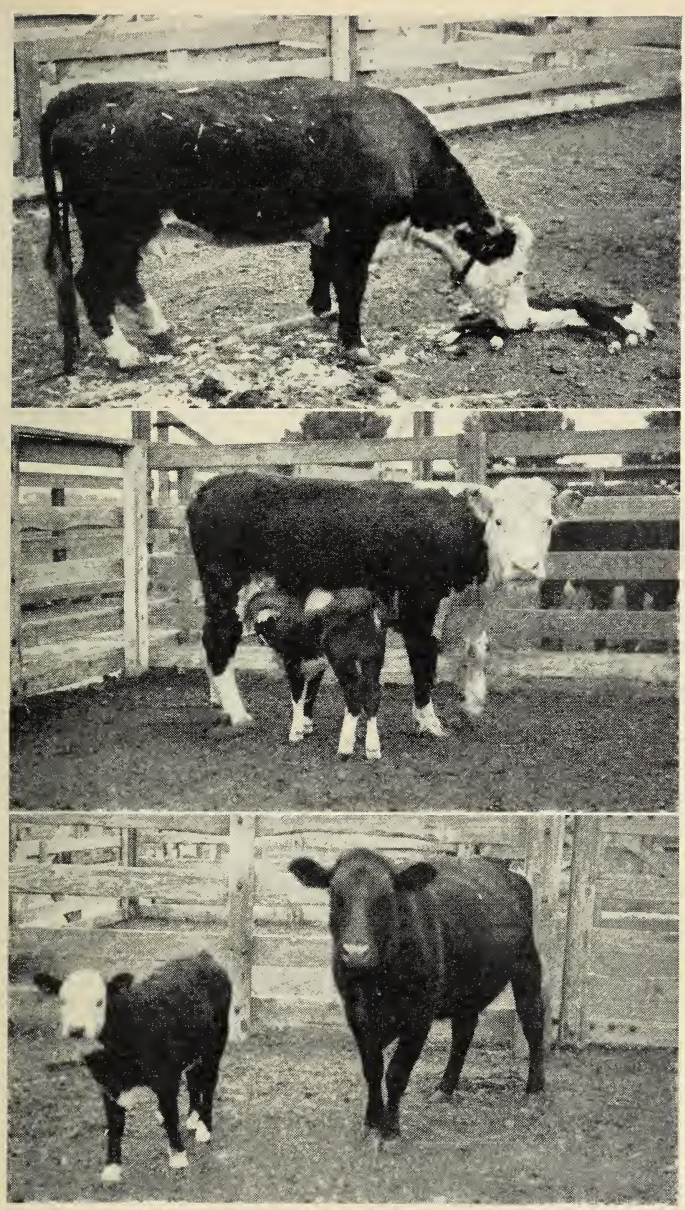

Fig. 24 (III). The heifer at the top received a ration deficient in vitamin A but otherwise complete; she became night blind and aborted during the last month of pregnancy. The heifer in the middle picture received the same ration, plus one pound daily of dehydrated alfalfa meal during the latter part of pregnancy, and produced a normal calf. The lower heifer received 15 cubic centimeters of codliver oil daily, containing 2,600 units of vitamin A per gram during a similar period; she likewise produced a normal calf. (From Ext. Cir. 115.)

mally if the water is warmed. The chronic, cumulative, poisonous effect is shown by the fact that the affected bony structures contain ten to fifteen times as much fluorine as similar bones of normal animals.

Poisoning by this element has been found in Modoc County in cattle, horses, and human beings. The waters from certain hot springs in Surprise Valley contain low toxic quantities. The trouble was readily prevented by keeping animals from drinking such waters over long periods of time.

Food and drug regulations take cognizance of the efficiency of defluorination of the rock phosphate used in animal feed.

Selenium. This element causes difficulties on the eastern slope of the Rockies

and on the Great Plains, but to date has not been incriminated in California. It is one explanation of the catch-all term "alkali poisoning" on the range. The primary source of the material was igneous rocks, which were broken down in early geological times, the selenium finding its way into sedimentary rock of Upper Cretaceous time and then into the Pierre and Niobrara formations. It is taken up from these areas by so-called converter wild plants. When these decay, selenium is returned to the soil in a form readily available to cultivated crop plants. The poisoning of animals results. This is the so-called "selenium cycle."

Affected cattle develop a dermatitis and a characteristic eroded condition of the horn of the hoofs. The subject is fully discussed in Bulletin 206 of the Wyoming Station (3) and in Technical Bulletin 2 of the South Dakota Station (4). According to this latter publication, molybdenum has been found in conjunction with selenium in some plants and is thought to have a secondary and probably additive effect.

Molybdenum. This is not generally considered a necessary element in animal nutrition although, according to Australian reports (5), extremely low levels of molybdenum in forage associated with what was considered normal copper content resulted in copper toxicity. Molybdenum is toxic when ingested even in minute amounts in forage. It is widely distributed in soils of granitic origin. As with selenium, some plants take up relatively much more of it than others. Britton and Goss of the University of California have found that it is present in toxic quantities in California. It is the causative factor of a long-known, obscure malady of cattle over wide areas in the San Joaquin Valley and in southern California. This abnormality is accompanied by changes in the color of the hair, by diarrhea, emaciation, and general unthriftiness; death may occur if the animals are left too long on the affected areas after symptoms appear. The symptoms appear mainly to be those of copper deficiency. That molybdenum interferes with copper assimilation or metabolism has been demonstrated. The growing of grasses which have a lower molybdenum uptake than legumes in pastures of affected areas and the use of copper supplement are the preventive practices currently indicated.

Cattle Feeds

Characteristics of Range Forage*

Annual Forage Plants. The principal forage plants of California foothill and valley ranges are annuals that germinate after the first autumn rains. They make varied amounts of growth during the winter, according to temperature and moisture conditions. From February to May is usually the period of greatest forage production. The relative abundance of different species varies with soil, seasonal distribution of rainfall, and closeness of grazing.

In general, the various forage species are, in the early stages of growth, high in water, protein, and minerals, and low in crude fiber. The dry matter of actively growing plants is much more digestible than that of the leaves and stems of the same plants in the mature stage; it has the characteristics of a concentrate feed rich in protein. The high moisture content in the early stages, coupled with the animal's difficulty in obtaining sufficient quantity, limits gains during this period. The various species of forage plants differ markedly in composition and nutritive value when mature and dry. Since the botanical composition of range forage may vary greatly from year to year, knowledge of chemical characteristics of the principal types of plants is valuable in judging the quality of the feed and in

* Unless otherwise indicated, data in this section are from: Hart, G. H., H. R. Guilbert, and H. Goss. Seasonal changes in chemical composition of range forage and their relation to nutrition of animals. California Agr. Exp. Sta. Bul. 543:1–62. 1932. (Out of print.)

selecting suitable supplements. These annuals may be broadly classified as flowering herbs, grasses, and legumes.

Of the flowering herbs or the broad-leaved plants, the filarees (*Erodium* spp.) are most important, often constituting more than 50 per cent of the total forage. In some areas other flowering plants may contribute significantly to the forage taken by cattle for limited periods.

Three species of filaree are widely distributed in California. Red-stem filaree (*Erodium cicutarium*) is found generally over the more fertile valley and foothill ranges. White-stem filaree (*Erodium moschatum*) is often found intermixed with red stem, especially in the coastal areas, and appears frequently in old cultivated fields. During the growing season, these species, together with annual grasses, produce very nutritious pasture. The broad-leaved species (*Erodium botrys*) and *Erodium botrys* f. *montanum* predominate, or may be found only on the poorer granitic, red, and gravelly soils, or on other soil in the oak and digger-pine belt of foothill areas. Livestock prefer the red-stem and white-stem to the coarser broad-leaved species. These are higher in protein and minerals and lower in fiber at comparable stages of growth than broad-leaved filaree and, under the same soil and moisture conditions, tend to remain green somewhat later in the season.

The filarees are high in calcium and total soluble minerals. The dry matter in the early stages of growth is rich in protein, but after maturity the amount is ordinarily too low to meet the requirements of cattle. Dry filaree is low in phosphorus, and the wide ratio of calcium to phosphorus is unfavorable to phosphorus utilization. The fiber increases with maturity and drying, so that total feed value becomes a limiting factor in producing gains. After long periods on dry feed the feces of cattle that are eating considerable quantities of filaree and other plants high in soluble minerals, remain moist and soft, whereas the droppings of cattle grazing exclusively on dry grasses that are low in ash, tend to become hard and dry.

A large number of species of annual grasses is widely distributed on California ranges. Wild oats (*Avena* spp.), bromes, fescues (*Festuca* spp.), and foxtail predominate. Wild oats and foxtail (*Hordeum murinum*) are generally abundant under good soil and moisture conditions, while bromes and fescues predominate in poorer soils. Closeness of grazing may also affect the relative abundance of different species. Under light grazing, or complete protection, taller-growing species, such as wild oats and often such objectionable species as ripgut, or needle brome (*Bromus rigidus*), flourish to the exclusion of shorter, finer grasses, filaree, and legumes.

Most of the grass species are palatable and nutritious in the early stages, but become deficient in protein and low in energy value at maturity. The available calcium and the total mineral content of dry grasses are low, in contrast to those of filarees and clovers. Phosphorus content is also low, as with filaree. The seeds of most species scatter quickly when matured and become relatively unavailable for grazing. Some seeds no doubt are obtained by cattle which graze on the fine leaf material on the ground. Seeds are relatively higher in phosphorus, and an abundant seed crop may increase the supply of this essential nutrient. Soft chess (*Bromus mollis*), probably the most desirable of the annual brome-grass species, retains the seeds in the seed heads for a considerable time, and these heads are grazed by cattle before the less nutritious stems are eaten. The seeds of foxtail and ripgut or needle brome, through mechanical injury to eyes and mouth, cause significant damage. The fiber content of grasses tends to be higher than in the red- and white-stem filaree and clovers and is of a tougher nature. Because of high fiber and low digestibility of the dry, mature grasses, the amounts that cattle

can consume furnish little more than the energy requirement for maintenance, even when protein and mineral deficiencies are corrected by supplemental feeding.

Legumes contain more protein than grasses and flowering herbs. Bur clover (*Medicago hispida*), an outstanding species, maintains relatively high nutritive value even in the mature dry state. The protein content may exceed 30 per cent of the dry matter in the early stages of growth. The amount decreases with maturity, but mature dry bur clover averages about 15 per cent protein, an amount more than necessary to meet minimum requirements of cattle. It is, therefore, a valuable supplement to other forage low in protein. The calcium and phosphorus content is adequate for nutritional requirements. Digestibility is relatively high, and gains continue when cattle have dry feed containing abundant bur clover. The plant is found on the richer, heavier soils; and early fall rains accompanied by warm weather make favorable "bur-clover years." The seeds and pods have about the same chemical composition as the combined stems and leaves. Many seeds are impervious to moisture and pass through the digestive tract apparently unchanged. The availability of the seeds of this species for grazing, however, contributes greatly to its nutritive value. Spanish clover (*Lotus americanus*) and hill lotus (*Lotus humistratus*) are less important representatives of leguminous plants. They usually constitute only a small percentage of the total forage on foothill ranges. Since they normally remain green after grasses and filaree have dried, they are relished at that time and extend the period of adequate nutrition of the animals.

Various species of vetch occur in the mountains and in some foothill areas. They are commonly called "pea vines" by stockmen and are relished by livestock.

Table 15 (III) shows the average chemical composition of many samples of these types of annual forage, collected at different seasons and from various range areas.

Perennial Grasses. Perennial grasses, together with sedges and rushes, make up the principal forage in higher ranges and mountain meadows. Perennial bunch grasses, in significant amounts, are found on some coast ranges; partially depleted stands respond to judicious grazing practices. Some bunch grass also remains in northeastern California ranges and in the high mountains. Salt grass (*Distichlis spicata*), a sod-forming perennial, occupies large areas of alkaline valley land, remains green most of the summer and provides fair forage for cattle. Bermuda grass occupies extensive areas of lowlands, and though it is a serious pest in cultivated crops, it furnishes good pasture for livestock during the summer. In chemical characteristics, all these grasses are somewhat similar, though some are much more fibrous and less palatable than others. The mature dry forage of the coarser, tall-growing perennial bunch grasses is low in protein, high in fiber, and relatively unpalatable. In general, the more fine leafy material there is available the more nutritious is the cured forage. Perennials have one outstanding advantage; they start growth more quickly and, being deep-rooted, remain green longer than annuals, a characteristic that prolongs the period of favorable feed conditions. Every practical means of encouraging valuable perennial grass species is desirable for improvement of the range feed supply.

Browse. Bluebrush (*Ceanothus integerrimus*), often locally called deer brush or sweet birch, is among the most important browse species in the foothills and mountains. Thick stands frequently develop after fires, and cattle make good gains on this as practically the sole forage for periods of from 2 to 4 months. Young stands of low-growing browse provide better forage than older plants, which eventually become too high for grazing

TABLE 15 (III)

Average Percentage Composition of Representative Annual Forage Species Showing Seasonal Changes*

Forage species	Crude protein	Nitrogen-free extract and fat	Crude fiber	Total minerals†	Calcium	Phos-phorus
Bur-clover:						
Early green stage	32.9	44.7	12.8	9.7	1.1	0.45
Bloom stage	24.2	49.2	18.2	8.4	1.5	.40
Seed stage	22.8	47.5	22.2	7.4	1.2	.32
Mature, dry	16.7	46.4	30.7	6.1	1.5	.24
Wild oats:						
Early green stage	14.2	57.4	22.0	6.4	0.41	.38
Bloom stage	10.0	54.7	31.3	4.0	0.24	.29
Seed stage	7.6	55.9	33.3	3.2	0.23	.25
Dry, seeds shattered	5.4	58.4	32.6	3.7	0.26	.18
Dry, leached	3.6	59.6	34.5	2.3	0.23	.11
Soft chess:						
Bloom stage	13.6	53.6	28.2	4.6	0.35	.37
Seed stage	11.5	59.1	26.1	3.3	0.31	.33
Mature, dry	7.7	60.9	28.0	3.4	0.35	.26
Dry, leached	6.9	60.5	30.1	2.5	0.41	.14
Red-stem filaree:						
Early green stage	29.8	45.4	11.3	13.5	2.2	.46
Bloom stage	17.8	51.1	18.8	12.3	2.3	.46
Seed stage	15.9	51.8	20.4	11.8	2.6	.38
Mature, dry	8.5	55.6	22.8	13.1	3.0	.18
Dry, leached	5.5	58.9	29.1	6.5	2.6	.14
Broad-leaf filaree:						
Early green stage	25.0	52.1	12.1	10.8	1.7	.39
Bloom stage	14.6	55.1	22.1	8.2	1.4	.35
Seed stage	11.2	54.0	27.0	7.9	1.4	.32
Mature, dry	6.4	57.2	28.3	7.9	1.7	.13
Dry, leached	5.9	58.6	30.0	5.9	1.9	0.08

* All figures are expressed on the basis of moisture-free samples.
† Total minerals represent silica-free ash.

cattle. Bluebrush decreases in phosphorus and increases in calcium as it matures, and this fact may help to explain why it is poor forage late in the season. The stems and shoots also become tough, particularly on old plants; as a consequence, the animals may have difficulty in getting a fill of leaves, whereas early in the season they browse on the leaves and the tender shoots. Bluebrush contains a saponin, the toxicity of which for cattle has not been demonstrated.

The seasonal changes in composition of bitterbrush (*Purshia tridentata*) and mountain mahogany (*Cercocarpus montanus*) appear to be similar to those of bluebrush. Among other species that may contribute considerable forage in some areas are serviceberry (*Amelanchier alnifolia*), coffeeberry (*Simmondsia californica*), poison oak (*Toxicodendron diversilobum*), and leaves of various oak species. Leaves of mountain white oak (*Quercus Garryana*) of northwestern California appear to be higher in feed value than those of other species. Various mesquite species and screw beans are important browse plants in some desert areas. The seeds and pods are rich in protein and are especially nutritious.

In general the protein content of browse species including desert and semidesert plants, such as sages (*Artemisia* spp.), winter fat (*Eurotia lanata*), and

shadscales (*Atriplex* spp.), is higher than that of dry grasses and weeds. If fairly palatable species are present in sufficient quantities, they constitute a valuable supplement to dry forage; by remaining green and succulent they provide carotene, the precursor of vitamin A. Spanish moss and mistletoe also have these supplementary values. Consumption of liberal quantities of mistletoe does not cause abortion in cattle or sheep. The chemical composition of various browse species is given in table 16 (III).

Acorns. In some years the acorn crop is heavy, and utilization of this large potential feed resource is an important problem. Stockmen are divided in opinion regarding the effects of acorns on cattle. Some report ill effects, while others claim that acorns aid materially in carrying cattle when other feed is scarce. The variations in results may depend on the kind of acorns and also on the nature of other available feed.

Different varieties of acorns vary in chemical composition, as is shown in

TABLE 16 (III)

AVERAGE PERCENTAGE COMPOSITION OF VARIOUS BROWSE SPECIES*

Browse and stages sampled	Crude protein	Nitrogen-free extract and fat	Crude fiber	Total minerals†	Calcium	Phosphorus
Bluebrush or sweet birch:						
Leaves and new shoots, May 9....	29.2	50.7	13.6	7.5	1.3	0.56
Leaves and new shoots, May 26...	20.7	56.2	15.8	7.2	1.0	.24
Leaves and new shoots, June 21..	22.5	60.1	10.0	7.5	1.9	.21
Leaves and seeds, July 8.........	24.4	59.6	9.5	6.5	1.8	.22
Leaves and few seeds, August 22..	16.9	65.4	10.9	6.8	2.5	.12
Leaves only, September 19.......	14.3	71.8	6.9	7.1	2.0	.11
Seedling twigs and whole plants, July 23..........................	25.0	57.1	11.3	6.6	0.8	.31
Bitterbrush:						
Leaves and twigs, May 19.........	15.0	62.8	18.7	3.5	0.72	.24
Leaves, August 6.................	13.3	65.3	16.1	5.4	1.5	.18
Leaves, September 14............	11.6	68.2	16.2	3.9	1.2	.13
Mountain-mahogany, August 7.....	16.1	55.1	22.6	6.3	1.2	.13
Chokecherry, July 23...............	21.5	63.3	9.3	5.9	1.4	.25
Oak leaves:						
Mountain white oak, August 15...	18.7	....	....	....	0.8	.26
Mountain white oak, September 20	16.3	....	....	....	0.9	.17
Mountain white oak, October 15...	14.3	....	....	....	1.2	0.30
Mountain white oak,‡ September.	15.7	47.8	17.0	9.9	....	....
Blue oak,‡ September............	8.8	41.3	35.2	9.8	....	....
Canyon live oak,‡ September....	11.4	38.1	30.6	10.0	....	....
Black oak,‡ September...........	8.6	50.1	20.3	9.9	....	....
Poison oak leaves,‡ September.....	7.2	50.3	26.6	9.2	....	....
Serviceberry, large-leaved§.........	14.3	60.1	23.6	1.9	....	....
Serviceberry, small-leaved§........	16.1	61.7	14.4	7.7	....	....

* All figures are expressed on the basis of moisture-free samples.
† Total minerals represent silica-free ash.
‡ The tannin analyses of these samples varied from 5.3 to 14.6 per cent and are not included with the nitrogen-free extract and fat. The total of the protein, nitrogen-free extract and fat, fiber, and ash does not therefore equal 100 per cent. Data from: Mackie, W. W. The value of oak leaves for forage. California Agr. Exp. Sta. Bul. 150:1–21. 1903. (Out of print.)
§ Data from: Dayton, W. A. Important western browse plants. U. S. Dept. Agr. Misc. Pub. 101:1–213. 1931.

TABLE 17 (III)

PERCENTAGE COMPOSITION OF ACORN SAMPLES

Material	Mois-ture	Crude protein	Crude fiber	Fat	Ash	Nitro-gen-free extract	Cal-cium	Phos-phorus	Tan-nins
Black oak (*Quercus Kelloggii*)									
Shell	35.58	0.96	27.90	0.61	0.73	34.22	0.19	0.01	1.68
Kernel	38.35	4.29	9.25	14.70	1.28	32.13	0.06	0.07	1.85
Whole nut	37.60	3.43	14.07	11.05	1.14	32.71	0.09	0.06	1.81*
Quercus dumosa									
Shell	43.60	1.41	19.10	1.01	1.30	33.58	0.18	0.04	7.95
Kernel	44.88	2.63	3.68	4.34	1.02	43.45	0.06	0.05	4.07
Whole nut	44.58	2.29	7.96	3.42	1.10	40.65	0.09	0.05	5.15
Blue oak (*Quercus Douglasii*)									
Shell	41.34	1.47	20.52	1.41	1.83	33.43	0.23	0.02	6.96
Kernel	40.55	3.50	2.99	5.78	0.79	46.39	0.03	0.05	2.58
Whole nut	40.75	3.03	7.08	4.77	0.98	43.39	0.08	0.04	3.61
Water oak (*Quercus lobata*)									
Shell	36.23	1.99	21.28	0.54	1.64	38.32	0.18	0.05	5.86
Kernel	42.02	3.10	3.30	5.50	1.02	45.06	0.04	0.07	3.18
Whole nut	40.57	2.82	7.84	4.25	1.08	43.44	0.08	0.06	3.85
Interior live oak (*Quercus Wislizenii*)									
Shell	25.67	1.34	34.07	0.63	0.74	37.55	0.31	0.01	2.94
Kernel	30.80	3.49	5.80	17.77	1.08	41.06	0.04	0.06	5.00
Whole nut	29.80	3.08	11.24	14.47	1.01	40.40	0.09	0.05	4.60

* Another sample had a tannin content of 6.4 per cent, indicating that acorns from different trees vary in composition as well as in palatability.

table 17 (III). Some are high in oil, others comparatively low. Tannin content is likewise variable. High fat content, as well as tannin and other intestinal irritants, may contribute to diarrhea. All acorns are low in protein and minerals, but they have considerable value if the ration is otherwise complete.

In a feeding test in 1936 (6), 3 cows on the San Joaquin Experimental Range lost an average of 150 pounds in 2 months when fed all the blue oak acorns they would eat and given access to dry range forage. Similar cows in another pasture with few acorns lost only 25 pounds. One cow which was fed acorns after the green feed started, gained almost as fast as she had previously lost on dry feed.

Since green feed is seldom available on the range when acorns ripen and drop, a second trial was run in 1942, in which cottonseed cake as a supplement was tested. Three cows were hand-fed 10 to 12 pounds of blue oak acorns daily, in addition to natural dry forage on the range. Four were fed 10 pounds of acorns and 2 pounds of 43 per cent protein cottonseed cake daily in addition to dry forage. Between September 21 and December 30, the first group lost an average of 174 pounds per head, as compared with an average gain of 53 pounds for the second group, which received the protein supplement with the acorns.

This peculiar situation of weight loss being accelerated by the eating of acorns, and the counteraction by protein supplement so that the acorns have significant feed value, has been confirmed by cattlemen. Evidently, therefore, a bountiful crop of acorns should be regarded, not as a curse, but rather as feed that can be put to good use if supplemented with adequate protein concentrate.

Effect of Rain on Dry Forage. According to laboratory experiments (7, 8)

dry forage contains 8 to 20 per cent of water-soluble materials, most of which are leached out by rains after the forage has dried. Soluble carbohydrates make up the larger part of this loss, though the highest loss on a percentage basis is in the mineral, the loss of which may vary from 30 to nearly 70 per cent of the total mineral content. Nearly all the common salt is removed, a fact which partly explains the increase in salt consumption after late rains have "spoiled" the feed. The percentage loss of protein in laboratory experiments was 7 to 18 per cent of the total. The percentage of protein in the leached residue remains about the same, or may even be higher because of larger losses of other constituents. The crude fiber content of the residue after leaching is higher. Digestion experiments show a decrease in digestibility of all nutrients, except fiber, after the soluble ingredients are leached out by rain. An example of how apparently small changes in digestibility may affect nutrients available for gain is shown in digestion experiments with bur clover before and after it was leached by 0.7 inch of rain. In 20 pounds of bur clover there were 12.5 pounds of digestible nutrients before leaching and 10.7 pounds after leaching. Since about 8 pounds of these nutrients are needed to maintain a 1,000-pound steer, evidently with the unleached clover, 4.5 pounds would be available for gain; but with the leached, only 2.7 pounds. Although the leaching caused a decrease of about 15 per cent in digestibility, the nutrients available for gain would be decreased about 40 per cent. This percentage of decrease occurs under practical conditions, since animals are limited in the amount of total feed they can consume. The effect is apt to be greater than indicated, since removal of soluble nutrients, responsible for the taste of feed, decreases palatability. If range feed remains wet for a considerable length of time, further damage is caused by molds and other decomposing agencies. Moreover, there may be considerable loss of leaves that are shattered and beaten into the soil by heavy rain.

Characteristics of Harvested Roughages, Grains, and By-products

Legume Hays. Legume roughages, such as alfalfa and various clovers, are higher in protein (table 12, III) than other forage crops; the protein is of excellent quality, the calcium content is high, and, when well cured, the roughages contain liberal amounts of carotene and other accessory nutrients. For these reasons the legume roughages are especially valuable in combination with cereal grains and other carbohydrate feeds.

In tests at the Kansas Agricultural Experiment Station, gains of cattle were greatest on hay cut at the bud stage, next at one-tenth bloom, and least when mature. Hay from the early stages is somewhat laxative. Both for feed value and for yield of digestible nutrients, early to one-half bloom stages are preferable for cattle. Careful curing saves leaves, the most nutritious part of the plant; this results in higher protein content and in conservation of minerals and other important nutrients. Carotene is rapidly decomposed during curing and sun exposure, so that about 75 per cent is lost even under most favorable conditions for sun-curing. Nearly all carotene disappears in slow-cured, and in bleached hays. Proper haymaking increases not only feed value, but also yields per acre, and palatability; and it reduces waste in feeding.

Nonlegume Hays. California is a leading state in production of cereal hay, and large quantities are used in beef-cattle feeding. Grain hays are low in protein and calcium, compared with the legumes. As hay is ordinarily cured, most of the vitamin-A value is bleached out, but when there is a significant amount of green color, the amount of carotene present will suffice to prevent deficiency. California feeding tests and practical experience

have demonstrated that results comparable with those of alfalfa are obtained in fattening cattle when the protein and other deficiencies are properly supplemented. Mixed hays, such as wild oats and bur clover, and oats and vetch, are intermediate in character. The feeding of both legume and nonlegume roughage is frequently preferable to either alone. Meadow hay varies with the soil, moisture condition, and type of grasses and grass-like plants of which it is composed. Unless clover is in the mixture, meadow hays have much the same character as grain hays.

The Washington Station has shown by chemical analyses and by digestion trials that the medium dough stage of maturity is most desirable for wheat, beardless barley, and oat hays. The increased digestibility found for later stages is more than offset by shattering and leaf loss under practical conditions. Curing to conserve green color is important, not only for palatability but also to retain carotene.

Straw. As plants mature, nutrients formed in the green parts are largely transported to the ripening seeds; the straw that is left is low in protein, minerals, starch, fat, and vitamins, and high in fiber. The digestibility and productive value are much lower than in hays from the same plants cut at earlier stages. Chaff and leaf material have a higher value than the coarser stems. When economically handled and adequately supplemented, the straws can be marketed to advantage through cattle. Recommendations for their utilization are given in Section IV, "Production of Feeder Cattle," and Section V, "Fattening Cattle and the Dressed Product."

Silage. Corn and sorghum crops are better conserved if ensiled, rather than fed as dry roughage. Silage adds succulence and palatability to rations. Corn and sorghum silage require protein supplements. Total feed value, as indicated in table 12 (III) and confirmed by feeding tests, is about one half that of average-quality hay. The tonnage secured and cost of production in comparison with hay are important considerations. Cheap trench silos reduce the overhead cost. A small acreage of silage crops may often be a way of increasing the feed supply for wintering young cattle; when used with legume hay, this feed produces good gains without additional concentrate supplements. Silage is valuable in fattening rations and for all classes of cattle. Sorghum should be cut when the grain is mature, otherwise the silage may be too acid. Silage from legumes and grasses may be satisfactorily made by adding 60 to 75 pounds of molasses to each ton of green forage as it goes into the silo.

Roots and Tubers. The relative values of some roots and tubers appear in table 12 (III). When these feeds can be grown economically or when culls are available at low cost, they can be effectively utilized in cattle rations. Roots and tubers are high in moisture and low in fiber; the dry matter is highly digestible. Roots may be used in the same manner as silage. Sugar beets and potatoes properly fed are only slightly lower in value than corn silage. Sugar beets, mangels, and potatoes should be chopped or sliced. Stock should be gradually accustomed to such feeds, especially potatoes; too large amounts may cause scours. Because of solanine, a toxic substance present in small amounts, badly sunburned or sprouted potatoes should be fed only in limited amounts, as a matter of safety, although liberal quantities have been given to cattle without apparent injury. Care should be taken to supply adequate amounts of protein feeds when roots and tubers are used in the ration. An efficient way to store and to utilize root crops is to chop them into a silo along with corn or other silage, or with dry roughage sufficient to take up excess moisture.

Experience in Kern County, as reported by the county farm advisor, has shown that potatoes coarsely sliced and spread with alternate layers of chopped barley

hay give a very satisfactory silage, agreeable in odor and palatable to cattle. The hay made up about 20 per cent of the mixture. The silage settled and cured without packing in the trench silo. Heating in the ensiling process seemed partly to cook the potatoes, for afterward they were rather mealy.

Considerable quantities of potato meal, made by grinding sun-dried cull early potatoes, have been prepared and fed in the southern San Joaquin Valley. The potatoes are spread, one layer deep, on hard ground free from clods and are allowed to dry for about 2 months. At the end of this time they are very hard and are usually ground in hammer mills, which produce a somewhat powdery product. Mixing this product with molasses to reduce its dusty nature has been successful. Practical tests indicate a value about equal to that of barley when fed in well-balanced rations.

Grains. The common grains, although differing slightly in feeding value (table 12, III), are similar in general characteristics and are replaceable one for the other in cattle rations. All grains are relatively low in protein and should be fed either with legume roughage, young green forage, or with a protein-rich supplement. Grains are moderately rich in phosphorus, but are low in calcium. All except yellow corn are deficient in vitamin A.

Barley is the basic carbohydrate concentrate feed in California. Table 12 (III) shows the average value for digestible protein and total digestible nutrients. The normal range of variation in chemical analyses of rolled and ground barley is from 7 to 13 per cent total protein and from 4 to 8 per cent crude fiber. Immature barley that is not "well filled" may run higher in protein, but because of high fiber is lower in feeding value. Though the poorer grades of barley may be utilized, they are inferior to plump, heavy grain, especially in fattening rations. Barley is fairly palatable to cattle, but is best when combined with other concentrate feeds.

Grain sorghums, such as milo, feterita, and kafir, are lower in fiber than barley and slightly higher in feeding value. They may be used as the only grain in fattening rations, but they combine well with other grains, especially barley. Ground grain-sorghum heads have somewhat lower feeding value than the ground threshed grain. If, however, one allows for the included roughage by feeding increased amounts, results are comparable with those of threshed grain. The relatively high moisture content that may be found in threshed grain sorghums often causes molding during storage.

Wheat has a slightly higher feeding value than dent corn, but gives best results when it replaces not more than half of the concentrate ration.

Oats, although too bulky to make satisfactory fattening feed, are excellent as a grain for growing cattle and as part of the mixture in starting cattle on feed.

Dent corn ranks between grain sorghums and wheat in total feed value. Its nutritiousness, together with high palatability, makes it a most desirable fattening feed.

Mill Feeds. Mill feeds are most extensively used in California for dairy cattle and swine. When prices justify, they may be satisfactorily fed to beef cattle. For this latter purpose, however, they should seldom be used to replace more than 25 to 30 per cent of the concentrate ration for beef cattle. All of these feeds are palatable.

Mill-run, wheat middlings, and rice polish are higher in proteins than grains and comparable with them in total digestible nutrients.

Rice bran and wheat bran contain more fiber than grains and are somewhat bulky. Wheat bran is valuable in rations for growing cattle and in fitting animals for show or sale.

Beet By-products. Fresh pulp from the sugar factories contains 90 to 95 per cent water. When it is passed through a press, the moisture content is reduced to

between 85 and 90 per cent, and the product is called pressed pulp. Siloed pulp is wet pulp that has undergone fermentation similar to silage; eventually it forms a rather cheesy mass. The moisture content usually varies from 87 to 90 per cent in well-cured siloed pulp.

A small reduction in percentage of moisture greatly enhances the dry-matter content of wet-pulp products; for example, if, by pressing, the pulp moisture content is reduced from 94 per cent to 87 per cent, the dry matter is more than doubled. Since the moisture content of wet pulp is high and variable, the sugar factories should adjust the price on the basis of dry-matter content, and feeders should compare the cost of digestible dry matter with that of other common feeds.

Dried molasses beet pulp is produced by spraying or mixing molasses with wet pulp and dehydrating the two together. The dried product commonly contains 8 to 10 per cent of moisture. The amount of molasses in it is variable, but probably averages about 30 per cent of the total dry matter, when molasses is plentiful.

All beet-pulp products are low in protein and deficient in phosphorus.

Beet pulp is bulky and has physical characteristics resembling roughage. Since the fiber is highly digestible, however, the feed value of the dry matter is comparable with that of barley. Beet pulp is an excellent feed to combine with barley. Such a mixture may be fed more heavily without danger of digestive disturbances.

Beet tops consist of the leaves and the crown of the plant. The dry matter in tops averages a little over 10 per cent of the beet tonnage. About 40 per cent of the dry matter is in the crowns, and 60 per cent in the leaves. Average figures for digestible composition appear in table 12 (III). The first text table at the bottom of the page shows the wide difference in composition between the crowns and the leaves.

The high ash content of the leaves contributes to their laxative effect. They may also contain 3 to over 6 per cent oxalic acid, an intestinal irritant. The amount decreases during curing and ensiling, and apparently oxalic acid is also decomposed to some extent in the rumen. Cattle on beet tops consume much water, and urinate frequently. The high soluble-ash content of the leaves and the presence of betaine and other nonprotein nitrogen compounds contribute to this effect. The fiber content of beet tops is low, and the digestibility and replacement value in terms of other feed is comparatively high, especially when this material is used in limited quantities with other feeds. The moisture content of fresh tops is about 80 per cent, field-cured tops 20 to 30 per cent, and beet-top silage about 70 per cent.

Maynard (9) has summarized data on the feed value of beet by-products. His figures, based upon digestible nutrient content, are derived from feeding tests; they are expressed in terms of the amounts of corn grain and alfalfa that the beet by-products would replace in the ration. The summary included 106 experiments, and the results appear in the second text table below.

	Crude protein	Nitrogen-free extract and fat	Crude fiber	Ash
Tops	9.0	59.0	13.0	19.0
Leaves	13.5	45.8	19.2	21.5
Crowns	8.1	80.2	6.9	4.8

	Corn and alfalfa replaced by by-products of 1 ton of beets		Corn and alfalfa replaced by by-products from 13½ tons average acre yield of beets	
	Corn, pounds	Alfalfa, pounds	Corn, pounds	Alfalfa, tons
Beet tops	46	150	620	1.01
Wet pulp	41.6	99.5	560	0.67
Dried pulp	80.2	37.6	1274	0.25

Thus, in livestock-feed production, the by-products of the sugar-beet industry are equal to the primary products of many feed crops; efficient utilization of these by-products is extremely important, not only to the livestock industry, but also to the stability of the beet-sugar industry. Information on utilization of beet by-products is presented in Section V, "Fattening Cattle and the Dressed Product." Additional data on sugar-beet by-product value and use have been published by Guilbert, Miller, and Goss (10). Making beet-top silage by stacking the green tops, drying them in the field, and either hauling them loose or baling them in the field is a practical method of conservation.

Dried Fruits and Fruit By-products. Fruits and their by-products are sometimes available at favorable prices for fattening cattle. They are all low in protein and high in carbohydrates. Prunes, raisins, figs, dried peaches, and dried pears are palatable to cattle and have been fed to mature animals in amounts of 4 to 6 pounds daily with satisfactory results. Reference to table 12 (III) will show their value relative to barley. When fed in excess, these fruits tend to be laxative. A good rule is to limit such feed to about 30 per cent of the concentrate rations. Dried apple pulp resembles beet pulp in composition and may be used similarly. Dried orange and other citrus pulps compare favorably with barley in total feed value. Dried pineapple pulp and raisin pulp are lower in feed value because of higher fiber content.

Molasses. Most of the molasses used in California is cane or blackstrap. Beet molasses, including Steffens discard, has been reported to be fairly similar to cane molasses in feeding value, although it is apparently less palatable and more laxative. Ordinarily feed analyses show Steffens-discard beet molasses to have 6 to 9 per cent protein. Much of this is not true protein, however, and its value for nutrition of cattle is questionable. The dry matter of cane molasses is low in protein; it consists largely of sugars, and about 9 to 12 per cent of mineral matter. The moisture content usually varies from 18 to 20 per cent. Molasses is very palatable but is laxative when fed in excess. In California it is commonly a cheap source of carbohydrates, and for this reason, may be used to the extent of 20 to 25 per cent of concentrate rations, or up to 10 to 15 per cent of the total ration, when grains and ground roughages are fed mixed. Fifteen to 20 per cent is about the right amount to mix with ground roughage to keep down dust and still not cake badly in storage. Molasses is also valuable in mixed ground rations to reduce dust; its palatability makes more effective the use of low-grade feeds. According to numerous experiments, molasses does not have a value in excess of that indicated by its digestible nutrients when added to an already excellent ration including a variety of palatable feeds. When other palatable feeds are included in the ration, molasses may be self-fed. It may also be poured or sprayed over grain or roughage in feed troughs or poured into troughs with grains or other feeds placed on top of it. Molasses at ordinary temperature weighs about 11.8 pounds per gallon. Thinning of molasses by heating is unnecessary with modern molasses mixers. Detailed information on methods of feeding and handling may be secured from the Agricultural Extension Service.

Brewery and Distillery By-products. Wet brewers' grains, unless pressed to remove part of the moisture, contain about 25 per cent dry matter. The fermentation process removes most of the starch, leaving a residue higher in fiber, protein, and fat, but lower in total feed value than the original grains. When fed fresh, wet brewers' grains are palatable and wholesome. Because of high moisture, souring and molding occur unless the feed is used within a short time after production. The digestible nutrient values for the dried grains are shown in table 12 (III).

Distillery slop contains about 94 per cent water. It can be fed to cattle by pumping into troughs. Molasses and grains can be added to replace the carbohydrates removed by fermentation. The recovery of dry matter in the slop is about 35 per cent of that in original grains. The liquid that may be strained off contains about 2 per cent dissolved solids. The dry matter is high in protein and fat, but distillers' corn grain is lower in fiber than brewers' grains. Because of high fat content, the total digestible nutrient value is higher than that of the original grain, as shown in table 12 (III). Distillers' rye grain is low in feeding value and relatively unpalatable.

Protein-rich Concentrates. In California, cottonseed meal or cake is the most commonly used protein-rich cattle feed. At times, however, soybean meal, linseed meal, fish meal, and other similar feeds are available in quantity and compete as economical sources of protein. One should always consider these feeds when purchasing protein supplements.

Cottonseed meal or cake varies in composition according to the manufacturing process. Whole-pressed cake contains the residue which remains after the oil has been pressed from the whole seed, including the hull. It is therefore higher in fiber and lower in protein than cottonseed products obtained from hulled seeds. Whole- or cold-pressed cake is soft and bulky and is therefore sometimes preferred for starting cattle on feed or, when the price is favorable, for using large quantities as a fattening feed rather than as a protein supplement. Only limited quantities are available. Cottonseed meal or cake, other than the cold- or whole-pressed cake, is available mostly in two grades, namely, of 41 per cent protein and 43 per cent protein; it is sold in various forms, such as nut-sized, sheep-sized, or pea-sized cake, and as meal. Cottonseed by-products contain small amounts of a toxic substance called gossypol. This does not, however, appear to have a toxic effect on cattle, except perhaps on very young calves. The so-called poisonous effect experienced with cattle is now known to be vitamin-A deficiency, which occurs after varying periods when no green forage or hay is included in the ration. Dairy cows at the Oklahoma Agricultural Experiment Station have been fed an average of over 10 pounds daily of cottonseed meal through three successive gestation and lactation periods without ill effect, when sufficient carotene, the precursor of vitamin A, was present in the hay. Whole cottonseed, because of its oil content, is higher in digestible nutrients but lower in protein than the meal or cakes. It is a satisfactory feed and may be used when the price makes it economical.

Linseed meal, although somewhat lower in digestible protein than 43 per cent cottonseed meal, has given results equal or superior to cottonseed meal in numerous experiments with fattening cattle. The protein content of the linseed meal used in these tests probably averaged about 30 per cent digestible protein, as compared with 34 to 35 per cent digestible protein in 41 to 43 per cent protein cottonseed meal. Linseed meal produced in California usually ranges between 28 and 30 per cent total crude protein and 24 to 25 per cent digestible protein; more is therefore required than of cottonseed meal to balance low-protein rations. Linseed meal is slightly laxative, appears to have a tonic effect, and is particularly credited with the production of "bloom" and fine condition of hair.

Fish meal of high quality, low in free fatty acids, is an excellent protein feed having about 40 per cent more digestible protein than cottonseed meal. Cattle take it readily in mixed rations and range calves at weaning time have been taught to eat it alone in a few days.

Meat meal, or tankage, has also been successfully used as a protein supplement in fattening rations; its value was about proportionate to the digestible protein content.

Sesame meal is palatable, gives excellent results as a cattle feed, and has about the same value as 43 per cent cottonseed meal. Soybean meal is slightly higher, both in digestible protein and in total digestible nutrients, than 43 per cent cottonseed meal. Feeding tests with cattle show practically equal values for sesame and soybean.

Peanut meal is very similar in value to soybean and cottonseed meal.

Coconut meal contains only about half the protein content of 43 per cent cottonseed cake, but is slightly higher in total digestible nutrients. It is fairly palatable to cattle when fed with other concentrate feeds.

Perilla meal, hempseed meal, and babassu meal are relatively new feeds and appear on the market in limited and variable quantities. Details of digestion experiments on these feeds are given in Bulletin 604 (11).

Mixtures of protein concentrates have in general been superior to some of the individual protein feeds fed alone.

Preparation of Feeds

All small grains, such as barley, wheat, grain sorghums, and oats should be ground or rolled for cattle feeding. Some feeders prefer rolled to ground barley because it may be more uniform and less wasteful to feed in windy weather. Where there is no wind loss, a careful feeder will obtain the same results from either ground or rolled grain. For cattle feeding, medium to coarse grinding is preferable to fine, and the cost of grinding is much less. Dent corn need not be ground for cattle, if hogs are run with them to recover the waste; otherwise, corn should also be ground.

Chopping or grinding of hay or other roughage decreases necessary storage space, saves waste, and sometimes labor, in feeding; but it does not increase digestibility. The saving of labor in chewing does not materially affect the net value of the feed. Fine grinding of roughage may actually decrease digestibility, probably because such forage does not remain for a normal time in the rumen, where it is subjected to bacterial digestion. Feeding of chopped or ground hay mixed with concentrates does not improve the nutritional value of the feeds used, nor make the ration better balanced than the same feeds fed separately, although there may be advantages in convenience and safety. As a rule the poorer the quality of the roughage, the greater the saving of wasted feed by chopping. On the other hand, the lower the price of the roughage the greater the saving must be to pay chopping costs. When a high quality of hay is properly fed in suitable racks there is little waste. If more attention is given to harvesting and curing of roughage, there will be less necessity for mechanical preparation. Frequently there is too much overhead cost in equipment and machinery for feed lots. Chopped hay requires only one third to one half as much storage space as long hay and slightly less than baled hay. Use of pick-up choppers, together with mechanical unloading devices, is a method which can save much labor both in harvesting and feeding. Information on types of mills, power requirements in relation to fineness of grinding, and grinding costs can be obtained from the Agricultural Extension Service.

Determination of the Most Economical Feeds

Ordinary feed analyses give the crude protein, nitrogen-free extract, fat, fiber, and ash content of feeds, but do not show the amounts of these constituents that are digestible, and, therefore, available to the animal. The value of individual feeds depends not only on the amount of digestible nutrients they contain, but also upon their palatability, their physical effect, and their use with other feeds to furnish the quantity and quality of protein, essential minerals, and vitamins necessary to form a *complete* ration. If

this information on individual feeds, together with rules and suggestions for using them in complete rations, is considered, then their relative values may be expressed with reasonable accuracy upon the basis of their *digestible protein* and total *digestible nutrients.* It should be recognized, however, that feeds may vary from the average analyses.

The last column in table 12 (III) gives approximate relative productive values of the various feeds, compared with barley. As experiments have shown, a pound of digestible nutrients from roughages has less productive value than a like amount from concentrates. The relative values in table 12 (III), therefore, give a more accurate basis for comparing the worth of concentrates and roughages, as sources of total productive-energy value at various prices per ton, than the digestible-nutrient figures for these feeds. Protein or nutrients content, other than energy value, has not been considered in this table.

When the prices of high- and low-protein feeds are about the same, one may select the cheapest by computing the worth of a series of feeds, compared with barley, and choosing from those the ones that will make a satisfactory ration. These should be the ones that are priced lowest in relation to their comparative value.

Example: If barley is quoted at $25 per ton, what is rice bran worth? Barley price, $25 per ton × 0.87 (the relative productive value factor for rice bran) = $21.75, the relative value compared with barley.

To determine the cheapest source of protein concentrates, one must consider both the digestible protein and the nonprotein, or the total digestible nutrients in such feeds. For example, about 2 pounds of coconut meal would be required to furnish the same amount of protein as 1 pound of 43 per cent protein cottonseed meal or cake. The 2 pounds of coconut meal, however, furnish also about 1.3 pounds of nonprotein digestible nutrients and would be approximately equal in protein and in total digestible nutrients to 1 pound of cottonseed meal plus 1 pound of barley. Therefore, adding the price of a ton of cottonseed meal to the price of a ton of barley and dividing by 2 would give the approximate replacement value of a ton of coconut meal. One can make similar comparisons for any feeds, in order to arrive at a rough estimate of their worth compared with the current market price.

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PRODUCTION OF FEEDER CATTLE

Percentage Calf Crop
Growth and Development of Feeders
Cattle Numbers Versus Feed Supply
Management Practices
Selling Policy

Analyses of cost studies, summarized in Section I, "The Beef Cattle Industry," show that four fundamental rules should be followed if feeds are to be marketed most efficiently through the production of feeder cattle.

1. Adopt a consistent, systematic breeding and culling program, as outlined in the Section II, "Physiological Processes and Cattle Breeding."

2. Secure, through breeding, management, feeding, and disease control, a high-percentage calf crop.

3. Promote, through feeding and management, normal and continuous growth of young cattle to secure efficient feed utilization and a desirable product.

4. Adopt production and selling policies that will yield the highest return from the annual feed supply.

In the subsequent pages, the application of these rules is presented.

Percentage Calf Crop

Since the primary function of the breeding herd is to produce calves, the breeding, feeding, and management of the cow herd are discussed in this relation. The principal factors controlling calf crop are as follows:

1. Plane of nutrition.
2. Season of breeding.
3. Proportion of bulls to cows and their distribution on the range.
4. Selection of breeding stock by proper culling.
5. Control of infectious diseases affecting reproduction.

Figure 25 (Sec. IV) shows to what extent weights of purebred beef cows and heifers varied during lactation and gestation periods, when abundant feed was available throughout the year. These cows, in high condition, did not change much in amount of body fat. The curves, therefore, reflect largely the changes in weight caused by the developing fetus, membranes, and uterine fluids and the loss at calving time. Pregnant cows must gain about 100 pounds between weaning time and calving in order to maintain their flesh. As the lower curve shows, heifers lose more weight than cows during the first 3 months of lactation. They must not only regain this loss but make additional gain before their second calving if they are to grow and develop normally. For this reason heifers are more sensitive to feed deficiencies than mature cows, and many heifers fail to breed under poor feed conditions.

Manual 2, a revision of Circular 131, replaces Extension Circular 115, *Beef Production in California,* by H. R. Guilbert and L. H. Rochford. Some tables and other data from the original circular are used in the manual.

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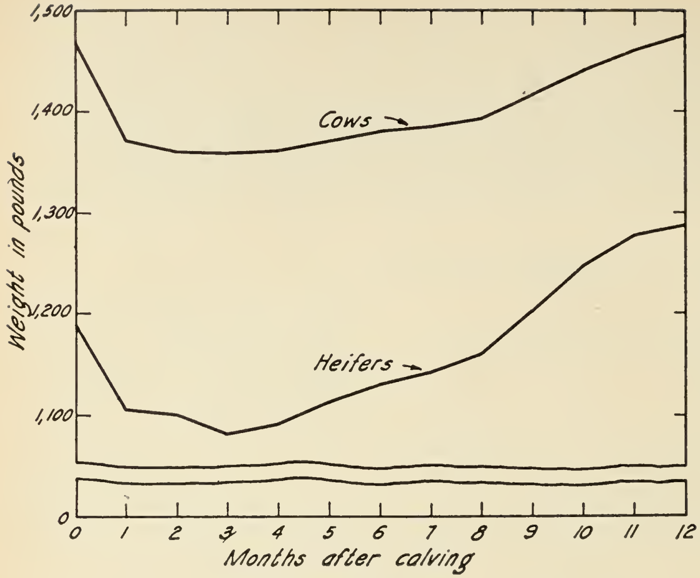

Fig. 25 (IV). Variations in average weight of purebred cows and heifers during the lactation and gestation periods. (Data from: Guilbert, H. R., and Alex McDonald. Weight records on purebred beef cattle during growth, gestation, and lactation, together with data on reproduction. Amer. Soc. Anim. Prod. Proc. 1933:244–53.)

The poorest feed conditions usually occur between weaning and the next calving. This is a critical period, affecting the next year's production. If cows or heifers just maintain weight, actually they lose about 100 pounds in condition, and are thin after calving. Below a certain plane of nutrition, either lactation or reproduction, or both, are impaired. Figure 26 (IV) illustrates such effects under range conditions.

Udder Development and Lactation. During the last third of pregnancy estrogenic hormone is produced by the placenta and, through action upon the anterior pituitary gland, stimulates growth of the secretory tissue in the udder. Similarly, artificial lactation in nonpregnant animals may be induced by implanting estrogen tablets under the skin.

Evidence with sheep (1), which appears equally applicable to cows, shows that good nutrition is very important if the development made possible by the hormone stimulation is to be realized. Ideally, the pregnant female should be in moderate condition up to the last third of gestation, then she should be fed liberally. Between a fat animal that loses weight during the last of gestation and a thinner one that gains rapidly, the latter tends to have the best udder development and subsequent lactation rate even though both reach parturition in the same condition. Thus, apparently, nutrition for udder growth must come from incoming nutrients rather than from body stores. The value of a high plane of nutrition before calving has long been recognized by dairymen, and it is frequently referred to as a "steaming up" process.

Poor lactation in many purebred cows may result from improper management as well as from heredity. When cows are already too fat, they cannot eat enough effectively to constitute "steaming up."

Range and Irrigated Pasture. A balanced production unit consisting of foothill range and irrigated pasture approaches the ideal for efficient yearlong production under California conditions. Such a set-up would usually comprise 10 to 15 acres of native range to 1 of irrigated pasture. The range forage may largely be utilized while it has high nutritive value; thus its productive capacity per acre is increased compared with yearlong use. Irrigated pasture provides adequate nutrition during the dry season

when range forage has low value. Excess pasture growth in the spring may be made into hay for supplemental feeding during the winter months. Thus a yearlong supply of good feed may be provided, which is the basis for high percentage calf crop, adequate milk supply, heavy weaning weights, and continuous growth and development of young animals. Properly managed, such a program can produce good quality well-finished beef at young age with little help from concentrates. This is one of the most important objectives confronting the beef cattle industry.

Cattle alternating between native range and irrigated pasture have advantages over yearlong use of either type of land. Continuous heavy concentration of animals on a limited area increases the difficulty with parasites. Generally the irrigated lands are not desirable during the winter because of poor drainage, muddy conditions unfavorable to the livestock, and damage to fields caused by trampling during rainy weather. During the growing season for native forage, good range provides a great variety of feed which has not been equaled as yet in cultivated mixtures for general nutritive effect and well-being of animals. Furthermore, the cheapest gains are usually produced from native feed.

Supplemental Feeding of Cows on Range. The characteristics of the principal types of range forage are discussed under "Nutrient Requirements and Cattle Feeds." Because of the high-protein and total-nutrient value of bur clover, ranges containing an abundance of this forage will maintain stock in good condition late into the dry season. On most ranges having annual-type forage, either bur clover and other legumes are lacking or the supply is inadequate to supplement other forage throughout the dry season. On the poorer type of grass-filaree ranges, the cows usually continue to gain through June, maintain weight through July, and begin losing in August. This occurs although forage is abundant and the cows are not suckling calves. On better ranges weight losses coincide with the time when the most nutritious forage has been exhausted through selective grazing and the protein content of the forage eaten falls below 7 or 8 per cent of the dry matter.

Fig. 26 (IV). The cows in the upper picture lost weight in the fall on range feed alone, were thin after calving, and became weak on continued scant feed. They produced calves that averaged 386 pounds at weaning time, and had only a 61 per cent calf crop the following year. The cows in the lower picture were on the same range feed, which was supplemented with sufficient cottonseed cake and barley to maintain flesh. They produced calves that averaged 481 pounds at weaning, and they had a 91 per cent calf crop the following year. (From Ext. Cir. 115.)

Protein supplements are therefore best for securing effective use of such ranges. Heavy weight losses occur at the time of the first autumn rains. The feed value of the old forage is reduced by its being leached and beaten into the ground; the new forage is too scant and watery to supply sufficient feed. Greater total nutrients as well as increased protein are needed at this time. When a significant quantity of the new feed develops, adequate protein and minerals may be supplied, although total feed value may still be low. The supplement can, therefore, be changed to grains or other carbohydrate feeds at this time if they are cheaper sources of total digestible nutrients than protein feeds. This may be an important means of economizing when cold weather retards the growth of the new forage for a long period.

Information and suggestions for meeting these conditions follow.

1. The main objective should be to feed whatever kinds and amounts of feeds will most economically overcome the existing deficiency and keep the breeding cows in thrifty condition. Actual amounts will vary with the type of range and the condition of the cattle. Supplementary feeding pays if it is done well enough to produce results.

The nutrient requirements appear in tables 10 and 11 (III) under "Wintering Pregnant Heifers" and "Wintering Mature Pregnant Cows." In establishing these requirements for mature cows, consideration has been given to the data on average weights of breeding cows that have been sufficiently improved through breeding to show strongly the characteristics of any of the three dominant beef breeds. Generally, according to these data, a weight of not less than 1,050 pounds before calving is necessary to support consistently regular rebreeding and maximum lactation, and to produce optimum weights in the calves. Gains and feed requirements in tables 10 and 11 (III) depend on the assumption that the cows are potentially of the same size and that differences in weight are largely due to condition—the situation generally encountered on the range. The gains during a 150-day wintering period and the nutrient requirements are those necessary if the lighter-weight cows are to attain about 1,050 pounds before calving. Using the data from tables 10 and 11 (III) on requirements and from table 12 (III) on composition of feeds, table 18 (IV) was prepared to show the relative adequacy of range forage when bur clover constituted 40 per cent of the feed intake, the inadequacy of 18 pounds' daily intake of dry filaree and grass, and the effect of 2 pounds of cottonseed cake in relieving the deficiencies.

2. A supplement fed daily over a longer period results in better range utilization, and is more effective than heavier feeding begun late, after weight losses occurred.

3. Results on the San Joaquin Experimental Range suggest the approximate amounts of supplement and the feeding schedule that may be necessary to maintain high calf crop and to produce heavy weaner calves on the poorer types of grass-filaree range. One pound of cottonseed cake was fed daily during August. From September to the first rains $1\frac{1}{2}$ to 2 lbs. daily were fed. Then, supplements were increased to 3 lbs. daily, then gradually decreased as new forage developed.

If cold weather results in slow growth of new feed, as much as 5 pounds daily may be necessary for cows that have calved during this period. The supplements per cow will usually total 250–300 pounds when fed as indicated. The resulting increased crops of heavier calves, worth more per pound, have yielded good profits on this added expense. On better ranges, the amounts required will be less, or supplements may be unnecessary.

An average of seven years' data, 1937 to 1943, on the San Joaquin Experimental Range, comparing supplemental feeding as outlined above with no supplemental feeding, follows.

	Group A, fed supplements	Group B, not fed supplements
Percentage of pregnancies	89.6	77.2
Percentage calf crop weaned	83.0	67.6
Average weaning weight, pounds	470.0	417.0
Average calf production per breeding cow, pounds	390.0	282.0
Average yearly supplemental feed, pounds	365.0	18.0*

* Fed one year only, to prevent excessive death loss.

An average of 365 pounds of supplemental feed yearly produced 108 pounds more calf weight per breeding cow in the herd; the heavier calves from cows receiving supplements were worth more per pound at weaning; and there was greater salvage value in these cows because of better weight and condition. Figure 27 (IV) shows the average weight curves of the two groups.

4. When barley and other grains are cheaper than cottonseed cake, the amount of cottonseed cake can be reduced and additional supplements selected from the cheapest sources of digestible nutrients. Three and one half pounds of average alfalfa hay contain digestible protein equal to that in 1 pound of 43 per cent protein cottonseed cake and double the amount of total digestible nutrients. Thus, about 4 pounds of alfalfa can replace 1 pound of cake and 1 pound of barley. When practical and economical, limited hay feeding may be substituted for concentrate supplements.

5. Feeding double amounts every other day is about as effective as daily feeding and reduces labor. If cows have been taught to eat supplements as calves, no difficulty in getting them to eat will be experienced thereafter. Cattle can be trained to come for feed when called.

6. Feeds like cottonseed cake can be placed on the ground in dry weather. Feed bunks placed at convenient places on the range are, however, preferable. They save waste, and the operator can use those feeds that are most economical, rather than be limited to one that may at times become exorbitant in price.

7. Self-feeding concentrates with salt in the mixture to limit consumption is being practiced on the range. Generally 25 to 40 per cent salt in the mix will limit concentrate consumption between 1.0 and 3.0 pounds daily. According to preliminary data from the San Joaquin Experimental Range, the amount of supplement consumed with a given salt concentration varied with change in forage conditions.

TABLE 18 (IV)

Nutrient Requirements of a 1,000-Pound Pregnant Cow in Relation to Nutrients Supplied by Range Forage Containing Bur-clover and by Forage Consisting of Filaree and Grass Supplemented with Cottonseed Cake

	Total feed, pounds	Total digestible nutrients, pounds	Digestible protein, pounds	Calcium, grams	Phosphorous, grams	Carotene, milligrams
Requirements	18	9.0	0.9	16	15	55
Dry range feed: 40 per cent bur-clover; 60 per cent grass and filaree mixture	20	8.5	0.9	79	18.4	0
Dry mixed broad-leaf filaree and grass	18	7.2	0.0–0.2	86	13	0
Cottonseed cake (43 per cent protein)	2	1.5	0.7	2	10	0
Total	20	8.7	0.7–0.9	88	23	0

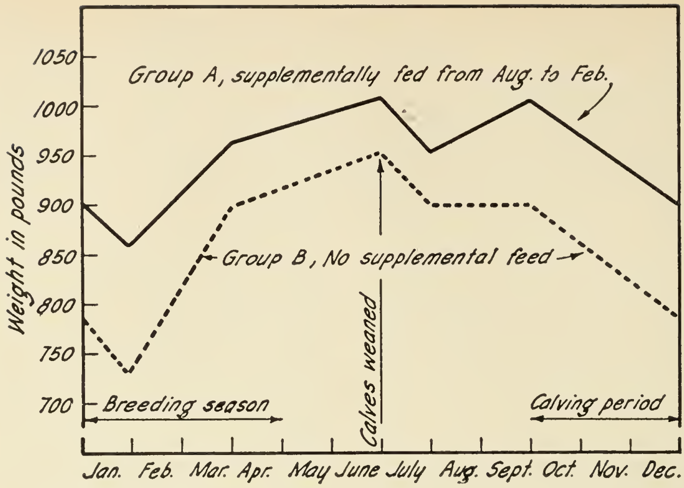

Fig. 27 (IV). Seven-year average-weight curves of the entire A and B groups of females of breeding age, including replacement heifers, on the San Joaquin Experimental Range. Weights are on the basis of 12- to 14-hour overnight stand without feed and water. Weight drop in July is partly due to culling of cows and adding lighter-weight replacement heifers. Cows of group A, four years old and over, averaged about 1,050 pounds before calving. This difference in average weight between groups caused by supplemental feeding, is reflected in the difference in production shown in the tabulation given at the top of page 5.

Apparently, therefore, a standard mix may not be relied upon to control closely the concentrate intake in relation to the needs of the animal. Such control is essential if optimum results are to be secured. When the salt percentage was varied to secure desired consumption levels, the results were equal to daily feeding of comparable amounts of supplement without salt. Actual salt consumption may vary from less than 0.5 to over 1.0 pound daily. Thus far no deleterious effects on cattle have been reported. Hofland (2) in Sweden reported that excess salt markedly reduced the microflora of the rumen. Cardon (3) of the Arizona Agricultural Experiment Station reported no detrimental effect on digestion. Access to a plentiful and conveniently placed water supply is essential, for the animals must drink large quantities to enable them to excrete the excess salt. If the labor cost is sufficiently reduced or supplemental feeding made possible where daily feeding is impracticable, the practice has real merit.

8. First-calf heifers and the thinner cows may need extra feed and special care. Where practicable, the segregation of such animals from the main cow herd, to allow feeding according to needs, increases the effectiveness of supplements used.

A systematic supplemental feeding plan such as this one provides adequate protein and phosphorus and adds materially to the total energy intake. It results in larger calf crop, heavier calves, shorter breeding season, less trouble in calving, fewer retained placentas, and lower death rate, and permits early calving.

On ranges where there is no browse or other source of green forage, a prolonged dry season may result in vitamin-A deficiency and calf losses. Such losses are especially probable when a short green-feed season intervenes between two long drought periods. Information and recommendations for this special type of supplemental feeding are presented as follows:

1. Nonlactating animals with meager reserves may store, in 4 or 5 months on

green feed, sufficient vitamin A to protect them for 6 to 7 months on dry feed.

2. Lactating animals, under similar conditions, possibly store less on green forage, and their reserves become depleted more rapidly when on dry forage. Heifers have less storage than cows under similar feed conditions and therefore become depleted in shorter time.

3. Cows and heifers may produce weak calves that die soon after birth, or die after a few days, of diarrhea, without themselves showing symptoms of deficiency.

4. If vitamin-A reserves are depleted during the latter part of pregnancy to the point where the cows are night-blind, premature birth of dead calves results. Because of the usual season of breeding, early abortions of small fetuses are not typical of vitamin-A deficiency.

5. If losses from vitamin-A deficiency are suspected, arrangements for diagnosis can be made through the local Agricultural Extension Service office or through a veterinarian. Diagnosis is made by tests on the liver of the fetus for vitamin A and the blood of the mother for brucellosis.

6. Losses from vitamin-A deficiency cease quickly when green forage becomes available or when suitable supplements are fed.

7. As an insurance against such losses when range forage dries early, supplements should be given a month or more before the beginning of the calving season if cows are bred to calve during the fall and early winter. Supplementing should be considered regardless of time of calving if the cows have subsisted exclusively on dry forage for 5 to 6 months.

8. Providing the breeding herd with Sudan or other green pasture, when possible, is a practical way of obviating vitamin-A deficiency. Even a few days on such forage will usually carry them over the critical period.

A daily intake of 55 to 65 milligrams of carotene during the last month of gestation will assure the birth of normal calves from cows whose reserves have been nearly depleted. It may be inadequate for subsequent lactation if new forage is further delayed. This amount of carotene will be supplied by approximately: (*a*) 15 to 20 pounds of hay containing only traces of green color; (*b*) 3 to 4 pounds of green alfalfa hay that would be called "good" by stockmen; (*c*) 2 pounds daily of highest quality sun-cured hay containing about 35 milligrams of carotene per pound; (*d*) 0.6 pound of dehydrated alfalfa meal containing 100 milligrams of carotene per pound. One may use table 13 (III) to estimate carotene content of feeds roughly by their appearance.

Since the feeding of several pounds of hay daily tends to act as a substitute for range feed, rather than a supplement to it, by discouraging the cattle from grazing, it is generally most practical to use concentrated sources. Dehydrated meal bought especially for this purpose should be analyzed for carotene, by a commercial laboratory, and the amount fed calculated on this basis.

9. Liver oils containing 2,000 to 20,000 U.S.P. units of preformed vitamin A per gram may, under some conditions, be a cheaper supplement than the sources of carotene mentioned. Such oils are tested, and their vitamin-A value is stated and guaranteed by the manufacturer. The requirement to assure reproduction in cows whose reserves are almost depleted during late stages of pregnancy is about 30,000 U.S.P. units daily. This will be furnished by:

a) About 15 cubic centimeters (approximately ½ ounce) daily of fish-liver oil containing 2,000 U.S.P. units per gram.

b) About 3 cubic centimeters (1/10 ounce) daily of fish-liver oil containing 10,000 units per gram, or 1½ cubic centimeters of oil containing 20,000 U.S.P. units per gram.

c) Two ounces of the highest-potency

TABLE 19 (IV)
EXAMPLES OF ADEQUATE RATIONS FOR WINTERING PREGNANT COWS, INITIAL WEIGHT 900 POUNDS

	Total daily feed, pounds	Total digestible nutrients, pounds	Digestible protein, pounds	Calcium, grams	Phosphorus, grams	Carotene, milligrams
Requirements	20	10	0.9	18	16	55
Rations in pounds:						
1. Alfalfa hay, 4; oat hay, 16	20	9.9	0.94	47	20	206
2. Oat and vetch hay, moderately green color	20	10.0	1.40	50	24	200
3. Alfalfa hay	20	10.1	2.16	137	19	388
4. Corn silage, 25; straw, 10; cottonseed meal, 1.5	18.8	10.2	0.84	14.4	19.3	158

oil, in a single dose, or one third of this amount fed on grain or other feed, in three doses, should supply enough vitamin A to protect against deficiency for a month. This vitamin in oil decomposes rapidly when mixed with other feed and, accordingly, should be added immediately before feeding.

The results of supplementary feeding as recommended are illustrated in figure 24 (III).

Wintering Cows on Harvested Roughages. Information and suggestions, particularly applicable to wintering cows in northeastern California counties, are itemized as follows:

1. The amount of feed required will depend upon the condition of the cattle, the amount of grazing, the severity of the weather, and the method of feeding to avoid waste.

The recommended nutrient allowances for wintering pregnant cows and heifers are given in tables 10 and 11 (III). Table 19 (IV), based on data from tables 10, 11 and 12 (III), shows how these requirements are met by rations containing common California feeds. As previously mentioned, these recommended allowances are based upon the nutrients required by cows, varying in weight at the beginning of winter, to attain a desirable minimum weight of 1,050 pounds before calving. Condition must be the deciding criterion of adequate feeding if cattle vary from average in size.

2. From 18 to 22 pounds daily of good-quality meadow or alfalfa hay, containing about 50 per cent total digestible nutrients, properly fed will produce gains and maintain condition. With lower-quality nonlegume hay, a pound of protein supplement daily is desirable, and larger quantities of hay may be required.

3. In case of hay shortage, each pound of grain or other concentrate feed may replace 2 pounds of roughage. Roughage should not ordinarily be reduced below 8 to 10 pounds daily.

4. Grains are satisfactory concentrate supplements to feed with alfalfa or other legume hays.

5. Three and one-half pounds of good alfalfa hay are about equivalent to 1 pound of 43 per cent protein cottonseed cake for balancing low-protein roughages.

6. Cows in strong condition in the fall can be wintered on grain straw that is supplemented with 3 to 6 pounds of good-quality legume hay or 1 to 2 pounds of cottonseed cake. Some forage of bright-green color is recommended to insure against vitamin-A deficiency. If no legume hay is fed with straw, cattle should have access to bone meal, ground limestone, or oyster-shell flour.

Although the ideal situation is to keep all animals in thrifty condition, some

cows and heifers may be thin at weaning time. These are most effectively and economically fed by separating them from the other cattle, by starting on feed early, and by more liberal feeding as indicated by the requirement data in tables 10 and 11 (III).

Planning the Breeding Season. Cows kept in thrifty condition through adequate feeding will breed readily and produce a high percentage of calves uniform in age. "Short-aged" or "off-season" calves are undesirable and should be avoided. Even if some sacrifice in calf crop must be made for one season, in order to adjust the herd to a short breeding period, timed to the feed conditions, the change will pay in the long run. If cows and bulls are in good condition, 3 to 4 months of breeding season is sufficient and results in uniform calf crops. This is particularly important in smaller herds from the standpoint of sales, especially of feeder cattle.

In areas with severe winter weather, the calf crop should be timed to come as early as possible and yet escape the danger of late storms. In the northeastern counties the bulls should usually be placed with the herd in June or July.

When one is operating yearlong on valley or lower foothill ranges, to have calving come in October, November, and December is possible and advantageous when the program of supplemental feeding as outlined is followed. Cows will milk sufficiently well to nourish the calves until new feed is abundant, and by this time the calves are large enough to take advantage of the forage as well as the full milk flow. Such calves can be weaned in July or August, at a weight of 400 to 500 pounds. They can then continue to gain on dry forage and supplements, and the cows are spared the drain of milking for a long period on dry forage. Most cows will breed late and therefore calve in the spring unless proper feed conditions have been provided during fall and winter. Spring calves are satisfactory when green forage is provided in the summer by valley or mountain ranges. Such calves are preferred by ranchers who have permits on the national forests, partly because calves under 6 months of age are not counted when going into forest range.

Bulls should be acclimated and in good condition when put into service. Those two to six years of age are generally most satisfactory. Older bulls may be used under good pasture conditions. Four bulls for each 100 cows are the usual number used on the range. Under rough range conditions the number should be increased. In a small field of good pasture a mature bull will serve 50 to 75 cows. Under range conditions a good rider who will keep the bulls and cows well distributed is valuable. On fenced ranges *rotation of bulls* is a practical way of increasing calf crop and reducing the breeding period. Under this system half the bulls are turned with the cows for 10 to 14 days; then these are taken out for rest and extra feeding and fresh bulls turned with the herd. After two such shifts all the bulls can be left with the herd during the remainder of the season.

By breeding under pasture conditions on the home range, by adequate feeding, and by rotating the bulls, some ranchers have decreased the number required, and have used the extra money to buy better bulls. The effect of this practice was an increased calf crop and a high percentage of calves dropped within a period of 6 weeks.

Age of Breeding Heifers. Growth and development rather than age are the best criterion for proper time of breeding heifers. As discussed under planning of the breeding season, there is usually one best time for calving in any locality. For this reason, few commercial cattlemen find it advantageous to plan regularly for both fall and spring calves; and choice is largely between breeding heifers as yearlings (12 to 16 months of age) or as

two-year-olds. For well-grown heifers in good condition, breeding at 18 months and calving at 27 months would be ideal. This practice is common in purebred herds. The Hereford Association does not permit registration of a calf born to a dam under 24 months of age. Breeding at 18 months of age in commercial herds would lead to "off-season" calves; and it is difficult to change the calving season by earlier breeding once a certain time has become established.

For commercial cattle, breeding replacement heifers at two years of age and calving first at three years are generally recommended.

The drain of gestation is relatively small, and pregnancy may even stimulate growth. A newborn beef calf usually weighs 65 to 80 pounds. About 75 per cent of this weight is obtained during the last 3 to 4 months of gestation. The calf contains about 15 pounds of protein and 3 pounds of fat. The feed requirement for pregnancy in addition to that for the cow's maintenance and growth is comparatively small.

In contrast to these small amounts of nutrients in the calf at birth, the milk produced in the first 4 months of lactation should contain about 65 pounds of protein, 70 pounds of fat, and 90 pounds of carbohydrates. The calf that required 9 months of gestation to attain a weight of 75 pounds should gain 225 pounds or more in the first 4 months after birth. These data indicate the comparative drain of gestation and lactation on the mother.

If breeding yearling heifers is to be recommended, the following conditions and practices are advisable:

1. Heifer calves should weigh 450 pounds or more when weaned, should be fed for normal growth (1 pound daily or more) from then to the next good grass season, and should weigh 650 to 700 pounds when bred.

2. The pregnant heifers should be fed liberally through the winter or the dry season so that they will grow and fatten enough to be in good-grade slaughter condition by calving time.

3. The heifers should be given assistance with difficult calving; a close watch at this time will prevent excessive loss of heifers and calves.

4. The calves should be disposed of for veal at 8 to 10 weeks of age to stop the drain of lactation, stimulate rebreeding, and permit normal development of the heifers.

5. Small-type (small-boned) bulls tend to produce smaller calves at birth than large-type bulls. Similarly, Aberdeen Angus calves tend to be smaller at birth than Herefords or Shorthorns, and Angus or Angus-cross calves tend to have shorter gestation periods than straight-bred Hereford calves. For these reasons, the breeding of yearling heifers to small-type or to Aberdeen Angus bulls might minimize difficult parturitions. The age of the bull does not affect the size of the calves. A bull of potentially large size will tend to sire just as large calves in his youth as in maturity.

If these practices are followed under favorable conditions, there is a good opportunity to increase the economic efficiency of beef production. Table 20 (IV) presents data from four ranches in Monterey County, where the general plan as outlined was followed. A group of two-year-old heifers at the time their calves were sold for veal is shown in figure 28 (IV).

The first calves from heifers calving as three-year-olds are commonly 50 pounds or more lighter than the offspring of mature cows because of lower birth weight and less milk supply. According to observations, however, at weaning time the second calves of three-year-old cows do not weigh more than the first calves of three-year-old heifers.

In a test of age at breeding, at the Kansas Agricultural Experiment Station, the calves were not vealed, but allowed to nurse to normal weaning age. As four- and five-year-old cows, those that had calved first as two-year-olds had calves

TABLE 20 (IV)—STATISTICS ON BREEDING YEARLING HEREFORD HEIFERS ON FOUR RANCHES, MONTEREY COUNTY*

Ranch Number	Number of years	Kind of bulls used	Number of heifers bred	Month and year heifers were bred	Number of calves sold	Average weight of calf at selling time, pounds	Average selling price per calf	Number of heifers died at calving time	Total pounds of meat from veal	Gross income from veal sold
I	7	2-year-old Herefords	677	April, 1936–37 February, 1938–39 May, 1940–41 June, 1942	362	222	$20.68	28	80,390	$ 7,488.75
	4	2-year-old Herefords	339	February, 1943–47	234	234	37.08	3	56,310	8,858.83
	1	2-year-old Herefords	85	February, 1948	59	338	94.78	1	19,972	5,592.16
II	1	Yearling Hereford	197	March, 1942	135	192	26.38	9	25,940	3,561.94
	1	3-year-old Brahman	20	February, 1948	15	291	87.20	0	4,365	1,308.00
III	1	Yearling Aberdeen-Angus	46	May, 1942	42	243	33.70	1	10,220	1,415.40
IV	1	Aged Hereford	43	April, 1942	23	243	29.10	0	5,579	669.48
			1,407		870			42	202,776	$28,894.56

* Data supplied by R. Albaugh, Assistant Farm Advisor, Monterey County.

significantly smaller at weaning than their mates of the same age that calved first at three years.

Unless early breeding is managed as recommended, the following disadvantages more than offset the extra calves obtained:

1. Heavy death losses of heifers and of calves at calving time.
2. Posterior paralysis and permanent injury to the genital tract at calving.
3. Stunting of heifers during the nursing period, and interference with intelligent selective breeding and culling.
4. Inferior calves, due to lack of milk.
5. Failure to rebreed, resulting in a large percentage of dry three-year-olds.

Diseases Affecting the Calf Crop. Contagious abortion, commonly called Bang's disease or *Brucella* infection, is the most common infectious cause of calf losses. This disease is characterized by abortion of fetuses from early to late stages of pregnancy and by placentas commonly retained. Diagnosis is made by means of a blood (agglutination) test. Infection is spread largely through feed and water contaminated by discharges from cows—rarely from bulls. Veterinary advice should be secured regarding diagnosis and control measures, including vaccination. Only a small percentage of cows abort the second time under range conditions. Some cows carrying and spreading infection do not abort at all. Culling out all known aborters under these conditions and replacing them with susceptible heifers may keep the disease active rather than build up herd immunity.

Trichomoniasis is a venereal infection transmitted by the bull. It is characterized by very early abortions of decomposed fetuses. Frequently vaginal discharge and recurrence of "heat" in cows thought to be pregnant are the only signs of this disease. It is difficult to diagnose definitely under range conditions. Disposal of infected bulls is the principal remedy.

Fig. 28 (IV). Well-grown two-year-old heifers weighing over 800 pounds at the time their calves were sold for veal. These heifers calved satisfactorily and rebred for the next calf crop without significant effect on their growth, development, and future usefulness. (Photo by Reuben Albaugh.)

Vibrio foetus apparently causes more abortion than heretofore supposed. It generally has been considered a self-limiting disease of minor importance. The organism can be transmitted by the bull and also in semen used in artificial insemination. Improved techniques have facilitated definite diagnosis, but no effective means of control or treatment have yet been established.

In dealing with any of these disease problems one should seek veterinary advice.

Growth and Development of Feeders

The Principle of Continuous Growth. An animal resembles a machine or a factory in that it is most efficient when operating at full capacity. Even under ideal conditions, nearly half of the total feed eaten is used for maintenance. The value in the practice of feeding for continuous growth is illustrated in figure 29 (IV).

The steers fed for maximum gain had access to good pasture along with the mothers until weaned, then were fed grain on pasture to promote rapid gain and finish. They weighed 900 pounds in less than 14 months and were "choice" slaughter cattle. This method of feeding is practical where a breeding herd is maintained under farm conditions with forage and grain plentiful.

The curve illustrating limited supplements fed represents a practical approach to the ideal under poor range conditions. A little more than 300 pounds of total

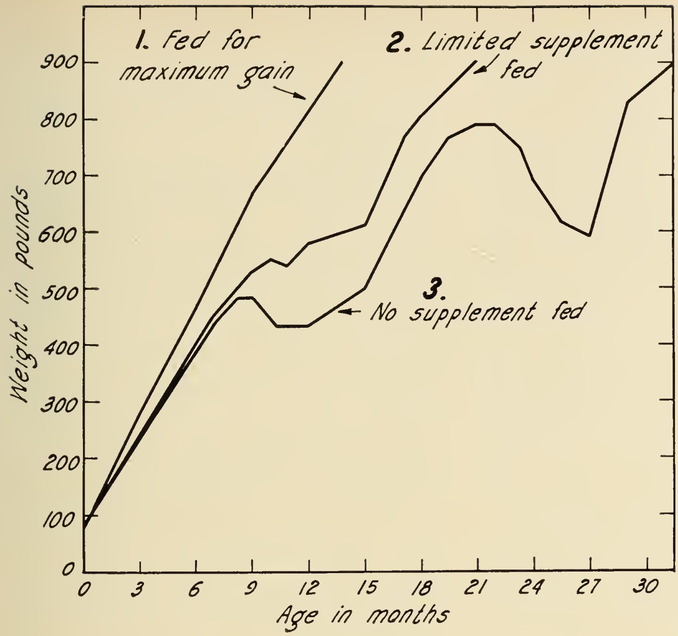

Fig. 29 (IV). Growth curves of steers showing the variation in time required to reach 900 pounds, as determined by feed conditions. (From Ext. Cir. 115.)

supplemental feed permitted these steers to gain continuously from weaning to the next grass season, and to attain a weight of 900 pounds and fleshy feeder condition in 21 months.

The steers represented by the third curve had the same breeding and the same range feed as those fed supplements, but they received no supplemental feed. They made no gain during the 6-month period from weaning until the next grass season, though dry forage was plentiful. They gained rapidly on good feed only to lose heavily again under adverse feed conditions. Obviously these steers that gained and lost and required 31 months to reach 900 pounds, ate much more total feed than those that required only 14 or 21 months to attain the same weight. They not only required more feed but also incurred added interest, risk, and other costs, and yielded a product of lower value.

The dry season (in the valleys) or the winter season (in the mountains) is usually the most costly period for producing gains. It is important to secure results so that cost per pound is reduced to a minimum. Calves or yearlings that gain well during the winter or dry season will gain somewhat less during the subsequent grass season than cattle that make no gain or lose weight. The problem is to secure economical gains during the high-cost period without subsequently minimizing cheap pasture gains. Numerous tests have shown that a gain of about 1 pound daily permits normal development, retains flesh and thrifty condition, and yet does not detract materially from subsequent pasture gains; it results in heavier cattle worth more per pound because of their higher condition and bloom.

A gain of about 1 pound per day for calves that will be sold as feeders at the end of the next grass season is a sound objective. If steer calves are to be finished as long yearlings by feeding on grass, 1¼ to 1½ pounds daily during the winter are desirable. Yearlings that make such gains can finish on grass under favorable conditions. Detailed experiments on the importance of continuous growth in beef cattle were reported in Bulletin 688 (4).

Supplemental Feeding of Calves and Yearlings on the Range. Suggestions for meeting the above-mentioned objectives under range conditions are given in the following five paragraphs.

1. Teach the calves to eat supplements while in the corral at weaning time. Unless green pasture or excellent dry forage is available, continue supplemental feeding when the calves are turned out on pasture.

2. On most dry range forage, 1 to $1\frac{1}{2}$ pounds daily of cottonseed cake or its equivalent in other protein feed will meet the requirements in table 4 (II) and will continue to produce gains until rains have leached out the forage. One may have to increase the supplement allowance to 2 or 3 pounds daily for the period when the old feed is spoiled by rain and new forage is scant. Decrease the allowance as feed improves and discontinue it when the new feed produces gains. If grains are cheaper, protein supplement can be held at 1 to $1\frac{1}{2}$ pounds, and grain substituted for the remainder of the feed. The results of this system of feeding are illustrated in figure 29 (IV). Steer calves fed in this manner weigh about 600 pounds in the spring and 850 to 900 pounds at the end of the next grass season. Heifers will be somewhat lighter in weight.

3. To finish with a short feeding period on grass as long yearlings, calves may have to be fed more liberally (3 to 4 pounds daily) during the fall and winter. Feeding of concentrates on the early green forage may sometimes be a practical procedure for speeding up gain while native feed is watery, and may be continued throughout the green-feed season.

4. For moderate growth of yearlings on dry feed, $1\frac{1}{2}$ pounds of cottonseed cake daily will suffice until the first rains. Subsequently, the feed required to continue gains and maintain condition is similar to that outlined for calves.

5. Utilizing foothill and valley range in the winter and spring and providing irrigated summer pasture or good mountain range are practical ways of continuing normal gains in young cattle and of decreasing the time when supplements are required.

Wintering Weaners and Yearlings on Harvested Roughages. No class of cattle responds more profitably to liberal feeding than calves during their first winter. It is much more important that calves be wintered well if they are to be sold as fleshy yearling feeders than if they are to be marketed as aged grass cattle or hay-fed beef. Often the calves remain too long with the cows in the fall, or feeding is not begun promptly at weaning time; consequently they lose weight and bloom. Liberal feeding from weaning time on is essential for best results. Tables 10 and 11 (III) show recommended nutritive allowances for wintering growing calves and yearlings. Feeding practices that have proved profitable and should produce $\frac{3}{4}$ to $1\frac{1}{2}$ pounds of gain daily are itemized as follows:

1. Provide well-drained corrals or other feeding places where the cattle have windbreaks and can find a dry place in which to lie down. Gains are difficult to obtain on young cattle even with abundant feed, unless they can be reasonably comfortable and can rest. In dry cold weather little shelter other than windbreaks is necessary. Favorable feeding conditions are as important as adequate feed.

2. Clean out mangers of the feed racks frequently to prevent waste in feeding and to provide fresh feed to induce optimum consumption.

3. When calves are allowed all they will eat of high-quality legume hay or mixed hay containing one half legumes, they will produce moderate gains under favorable conditions. The amount of hay varies with the size of the calves; from 10 to 15 pounds daily is the usual range.

4. With low-protein nonlegume meadow hay or grain hay, give, in addition to all the hay they will eat, $\frac{3}{4}$ to 1 pound daily of cottonseed meal or its equivalent.

5. For gains of more than 1 pound daily, 2 pounds of concentrates, in addition to all the roughage the calves will eat, are recommended. With legume hay, grain is satisfactory; with nonlegume hay, 1 pound each of high-protein feed and of grain are recommended (fig. 30, IV).

6. Ten to 15 pounds of silage daily with all the legume hay that the calves will consume (8 to 10 pounds), make an excellent wintering ration that produces good gains without concentrate supplement.

7. Calves wintered as indicated should weigh 500 to 600 pounds in the spring, 800 to 900 pounds at the end of the following pasture season.

8. Calves turned out on scant, early spring feed and given hay in addition frequently shrink. In their desire for fresh feed, they commonly do not eat much hay and therefore fail to get enough nourishment from the pasture.

An example of the effect on appetite, rate, and economy of gain resulting from using a protein supplement with low-protein and low-phosphorus roughage is shown in table 21 (IV) by the calf-wintering tests at the Nebraska Agricultural Experiment Station. The hay used contained only 5 to 6 per cent protein. The addition of 1 pound daily of cottonseed cake to the ration increased hay consumption and produced over six and one half times as much gain; and 168 pounds of cottonseed cake saved nearly 3 tons of hay for each 100 pounds of gain produced. Moreover, these calves averaged 66 pounds heavier at the end of the next grass season.

In the Colorado trials shown in table 21 (IV), cottonseed cake was a supplement to palatable meadow hay containing

TABLE 21 (IV)

RESULTS OF FEEDING CONCENTRATE SUPPLEMENTS WITH HAY FOR WINTERING CALVES

	North Platte, Nebraska* (average of 5 trials, 10 head per lot)		North Park, Colorado† (average of 2 trials, 32 head per lot)	
	Prairie hay	Prairie hay plus 1 pound cottonseed cake daily	Mountain meadow hay	Mountain meadow hay plus 0.8 pound daily of cottonseed cake
Winter period—feeding hay with and without supplement				
Number of days in winter period	170	168	150	150
Average initial weight, pounds	408	405	408	410
Average final weight, pounds	433	570	522	584
Average daily gain, pounds	0.15	0.98	0.76	1.16
Average daily feed, pounds	10:6	12.95	14.7	15.3
Feed consumed for 100 pounds' gain, pounds	7,220	1,320	1,940	1,330
Summer period—grazing without supplement				
Number of days on grass	148	146	159	159
Average final weight, pounds	692	755	770	804
Total summer gain, pounds	259	185	248	220
Average daily summer gain, pounds	1.74	1.27	1.56	1.38
Total winter and summer gain, pounds	284	350	362	393

* Brouse, E. M. Wintering calves in the Nebraska sandhills. Nebraska Agr. Exp. Sta. Bul. 357:1–29. 1944.
† Rochford, L. H. Summary of six range calf wintering tests. Colorado Agr. Ext. Service Report 1931. (Mimeo.)

Fig. 30 (IV). These yearling steers, when weaned at 8 months of age, averaged 546 pounds in weight. They were fed an average daily ration of 12 pounds mixed hay and 2.5 pounds grain per head during the winter, in which period their average daily gain was 1.3 pounds. Here they are shown on meadow pasture without grain, being held for sale as choice feeders. Note that proper care and feeding make gentle cattle.

8.5 per cent protein. It did not increase the consumption of this hay and improved the rate and economy of winter gains to a less extent than in the Nebraska trials.

In both sets of trials the cattle that received no supplement made greatest gains during the summer. The combined difference in total winter and summer gains in favor of supplements averaged 66 pounds in the Nebraska experiments. In the Colorado experiments, the difference in gain during both periods was only 31 pounds; but the cattle fed supplements showed more bloom and were appraised higher at the end of the summer than those wintered on hay alone. Since calves are usually not sold at the end of winter, the profit from supplemental feeding is really measured by the difference in weight and sale value at the end of the next grass season.

In California, numerous field tests with wild meadow hay, and with grain hay similar in composition to prairie hay, have given the same kind of results as the Nebraska trials; little or no gain was made during the winter. Feeding 1 pound of cottonseed cake and 1 pound of grain daily with the hay, however, resulted in winter gains of 1 pound or more daily. The record below is an example.

Table 22 (IV) gives examples of adequate and inadequate rations for producing 1 pound of gain daily, using tables 10 and 11 (III) on recommended allowances and table 12 (III) on the composition of feeds. Ration 1 is that fed in the Nebraska trials, with composition estimated on the basis of averages. Compared with requirements, the ration is low in total digestible nutrients, digestible protein, and phosphorus. The protein and phosphorus deficiencies reduced the total feed intake. The gain was only 0.15 pound daily. Adding 1.0 pound of cottonseed meal to this ration (ration 2, table 22, IV) brought the protein and phosphorus nearly up to recommended allowances

Date	Number of head	Average weight, pounds	Average daily gain, pounds
Feb. 12, 1937	92 steers	425	1.36
April 8, 1938	92 steers	608	
Feb. 12, 1937	72 heifers	395	0.82
April 8, 1938	68 heifers*	500	

* Four heifers killed for ranch meat.

TABLE 22 (IV)

ADEQUATE AND INADEQUATE RATIONS FOR WINTERING CALVES OF 450 POUNDS' INITIAL WEIGHT AND 600 POUNDS' FINAL WEIGHT

	Total feed, pounds	Total digestible nutrients, pounds	Digestible protein, pounds	Calcium, grams	Phosphorus, grams	Carotene, milligrams
Requirements: 450-pound calf	12	6.5	0.75	16	12	25
Requirements: 600-pound calf	15	8.0	0.80	16	12	30
Rations, in pounds:						
1. Prairie hay (Nebraska trial, table 20)	10.6	5.7	0.27	24	5	85
2. Prairie hay plus 1 pound daily cottonseed cake (Nebraska trial, table 20)	12.95	6.7	0.66	28	10	95
3. Weight 450 pounds: alfalfa, 10; barley, 2	12	6.6	1.23	68	13	195
Weight 600 pounds: alfalfa, 13; barley, 2	15	8.2	1.55	89	15.8	250
4. Weight 450 pounds: oat hay, 10, cottonseed cake, 1; barley, 1	12	6.33	0.76	13	17	80
5. Weight 450 pounds: corn silage, 20 (dry equivalent, 5.8); alfalfa hay, 6	11.8	6.8	0.83	49	13	236

and made the daily gain about 1.0 pound. As ration 3 shows, 10 pounds of alfalfa hay (about all a 450-pound calf will eat) with 2 pounds of barley meet the requirements for total digestible nutrients and phosphorus, and supply an excess of other nutrients. Increasing the hay to 13 pounds by the end of the period meets requirements for 600 pounds weight. Ration 5 illustrates another excellent feed combination for wintering. One can calculate other rations similarly by using the data in tables 10, 11, and 12 (III). As table 11 (III) shows, 53 to 55 per cent total of digestible nutrients is required in the ration. Excellent-quality roughage contains this amount and needs no concentrate supplement to meet this requirement. Average roughages containing 48 to 50 per cent total digestible nutrients should be fed with about 2 pounds of concentrate feeds.

Bleached hays containing no green color are deficient in carotene. One should therefore feed some green-colored forage, to prevent vitamin-A deficiency.

Yearlings may be wintered satisfactorily on the same types of feeds suggested for calves, except that larger amounts are required. There is less need for supplement other than for minimum protein; and more of the coarser feeds may be employed.

Adjustment of Cattle Numbers to Feed Supply

One important problem confronting cattle breeders and graziers is adequate provision for seasonal and annual variations in the feed supply. Adjustments to meet the situation must differ with individual ranches. The following suggestions, however, have proved practical for wide application:

1. Provide for a proper balance between summer and winter feed supply. This is as essential when cattle are maintained on a single ranch unit as when winter feed and summer feed are supplied by separate units.

2. Stock the ranges moderately, so that ample forage is available in average years for maximum gains, and excess forage waste through nonuse is avoided.

3. Build up a reserve of hay and other feeds in good years and in times of low prices, to meet drought and other extreme conditions.

4. Maintain some reserve of fat on breeding cattle so that weight losses can

be withstood in emergency without interfering with future production.

On foothill and valley ranches that normally carry cattle yearlong on the range without hay feeding, a hay reserve of at least ½ ton or preferably a ton per animal unit is advantageous. It is cheaper insurance against an extreme feed shortage than stocking so lightly that sufficient dry feed remains on the ground for the emergency of delayed fall rains. Dry feed is spoiled by rains and wasted from nonuse during average years, whereas hay under shelter can be kept for many years without significant loss of value. This policy permits as complete use of the range as is consistent with its conservation. As a result, one can secure higher returns in pounds of beef per acre without gambling on the drought years. In some areas silage is an excellent feed to reserve for emergencies.

The effect of trying to increase numbers over the feed supply was strikingly shown at the New Mexico Experiment Station. Under adequate adjustment of cattle to feed, cows averaged about 1,000 pounds in weight, the calf crop was about 90 per cent, and the calf weight at weaning about 400 pounds. When the same amount of feed was consumed by 30 per cent more cattle, the cows weighed 650 to 700 pounds, the calf crop was about 40 per cent, and the weight of calves 300 pounds or less. In the first case, it was estimated, 30 per cent of the feed went for calf production and 70 per cent for maintenance; in the latter, 90 per cent of the total feed went for maintenance, and only 10 per cent was recovered in production.

Management Practices

Dehorning. The advantages of dehorning are as follows:

1. Dehorned cattle require less space in feed lots, and eat more quietly; there is less fighting away of timid animals from feed.

2. Dehorned cattle require less space in shipment and are less apt to bruise and injure one another.

3. Dehorned cattle present a more attractive and uniform appearance.

For all these reasons there is price discrimination against horned animals, both as feeders and as slaughter cattle. The disadvantage of dehorning is the labor of the operation and the setback to the cattle. The younger the cattle are when dehorned, the less they are affected. In one test, when yearling cattle were dehorned after arriving at the feed lot, 15 days were required for them to regain weight; thereafter the gains were normal.

On California foothill and valley ranges where fall and early winter calves are practicable, dehorning can be done in January and February, when the danger from blowflies is least. This is a further advantage of early calves in these sections. For younger calves having "buttons" (small horns not attached solidly to the head) dehorning with caustic paste has been found satisfactory. Directions for using the caustic paste are supplied by the manufacturer. Some operators cut off the larger horns (up to about 1½ inches long) with a knife or with the spoon gouge, and lightly apply caustic to the wound. This has a cauterizing effect and is intended to destroy any horn cells not otherwise removed. Bleeding, however, may wash away the caustic, and some horn growth or scurs may develop. If the gouge is used carefully, caustic is unnecessary. Indeed, its use actually delays healing.

Another method of dehorning calves that has been favorably demonstrated in Monterey County is to cut the horn or button off with a large knife or dehorning shears close to and level with the head and then to sear the wound with a hot iron. The irons used are concave to fit over the horn area and have a burning edge ⅜ to ¼ inch in diameter. There are 3 sizes: the inside diameter of the small iron is about that of a dime; the middle iron, that of a nickle; and the

large iron, that of a quarter. The iron used will depend on the size of the wound. The success of this operation depends on the skill of the operator. The wound should be seared enough to stop any bleeding and to destroy any horned growth cells that might not have been removed by cutting. Caustic is not employed with this method.

For dehorning calves or yearlings with larger horns, various types of clippers or dehorning saws are used. In either process, a circle of skin, 1/4 to 1/2 inch in diameter, should be removed with the horn to insure a smooth poll. If the horn is taken off close to the head, one can reduce bleeding by pulling the two arteries lying between the skin and the bone on either side of each horn. For this operation sharp-nosed pliers are used. In pulling the artery, about 1/2 inch is removed, leaving a crushed end underneath the skin. With a little practice and suitable pliers, this can be done in a few seconds. Livestock-supply companies offer various powders and liquid applications that are more or less effective for reducing bleeding and repelling flies. If there is no danger of flies, and if instruments are kept sterile by dipping in disinfectant between operations, treatment of the wound is usually unnecessary.

If, because of the danger of maggots, dehorning cannot be done when the calves are very young, it is commonly delayed until the following winter or spring.

If wounds become infested with blowfly maggots or screwworms, the maggots can be killed with benzol, removed with swabs and forceps, and the wound treated with fly repellent. Pine tar and bone oil are common ingredients of such preparations. Castor oil poured into the wound is very effective in promoting healing and has some fly-repellent properties.

Adequate equipment, as the chute shown in figure 31 (IV), or a calf-marking table, results in better work and is much easier on men and animals than roping, "flanking," or "mugging." To use extra time for careful work is more profitable than to set a record for the number of cattle worked on per hour.

Castration. Bull calves can be castrated at any time from a few weeks to 7 months of age. Preferably, however, they should be castrated before they are 4 months old; if the operation is deferred until after 7 months, they will tend to show some stagginess. As with dehorning, there is less hemorrhage and setback with younger than with older animals. The usual method is to cut off the lower third of the scrotum, slit the membrane covering each testicle, force out the testicles, and sever the cord by scraping with a knife. Probably a preferable method is to pull the scrotum down, insert a sharp, thin-bladed knife entirely through from the side and about halfway up; then with one stroke slit the scrotum to the end. Remove the testes by pulling without removing the covering membrane. This method takes little time, insures drainage, rapid healing, and leaves the entire cod intact. There is little bleeding.

The hands of the operator and the knife should be kept clean and as nearly sterile as possible by being dipped in a disinfectant solution between operations. The wound should likewise be disinfected. Chlorazene solution, weak solutions of sheep dip, Lysol, or similar preparations are satisfactory. Danger of maggot infestation must be considered as in dehorning. Castration with burdizzo-type instruments crushes the cords without severing the scrotum, avoids blood loss and maggot infestation. If carefully done, this method is satisfactory. In actual practice, however, a higher percentage of cattle so treated show more stagginess than do those castrated with the knife. Castration by the "elastrator" method at about 30 days of age appears promising. Some difficulty and setback have occurred with larger calves.

Vaccination. Blackleg immunization through vaccination is an almost universal practice. Immunity should be es-

tablished as early in life as possible. On ranges of lower altitude, calves are commonly vaccinated when they are castrated and are branded in the late winter or early spring. In later-calving areas, calves are usually vaccinated at marking time and before they go to summer range. Although outbreaks may occur at any season, the greatest danger is in spring and fall. Single doses of modern vaccines immunize for life. Detailed directions are supplied by biological companies manufacturing the vaccines.

In anthrax-infected areas, routine vaccination is necessary. Veterinary service should be employed in all anthrax outbreaks.

Branding. All brands and marks must be approved and recorded by the Livestock Identification Service, California State Department of Agriculture, Sacramento. To avoid unnecessary damage to hides and to the animals, brands should be as small as is consistent with ease of identification. Since the brand increases in area with growth of the cattle, small brands may be used if the calves are only a few months old. Hot-iron branding is most commonly employed and, in general, is most satisfactory. Cold-iron branding, by using a caustic fluid, causes very little pain and, when carefully applied, makes a permanent brand in the skin. Since it does not change the direction of hair growth as does the hot iron, it becomes illegible when the hair grows out. Caustic branding fluid is therefore not recommended for general range use. Whenever possible, branding, castrating, dehorning, and vaccinating should be done before the calves are 4 months of age and while they are with their mothers.

Equipment. A good set of corrals and equipment is essential for efficient handling and management of cattle. Every effort should be made to work cattle quietly and easily, inflicting only a minimum amount of injury. This careful handling, together with culling of wild or nervous animals, results in gentle, easily worked cattle.

Equipment should include a calf chute and marking table, squeeze chute, parting gates, loading chute, and scales. The portable squeeze chutes and marking tables now sold cost practically the same as home-built ones. Figure 31 (IV) shows a satisfactory and inexpensive type of

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Some Branding Hints*

1. DO brand with a hot iron. You can't freeze on a brand with a cold iron.
2. DON'T let the iron get red hot. It may start the hair burning, and usually results in a poor brand. At proper heat the iron is about the color of ashes.
3. DON'T use a forge or a coal fire. Wood is the best fuel for heating the iron.
4. DON'T use caustic compounds. They may cause a bad sore and leave a scar rather than a brand. The result many times is unreadable. If you must use caustic, first clip the area to be branded.
5. DON'T use a small iron (horse iron) on cattle. The result is generally unreadable.
6. DON'T use a thin iron or one that is burned up. It may cut too deep or make a thin scar that the hair covers over.
7. DON'T join the letters of your brand—Æ. Such an iron will never heat or burn evenly. The result is usually a blotch.
8. DON'T try to brand a wet animal. The brand may scald the animal or leave a blotch or a bad sore. Also, it's likely to be unreadable.
9. DON'T feel sorry for the animal. The iron must burn deep enough to remove the hair and outer layer of skin. The smoke you see is mostly burning hair and the burn is practically painless.
10. DON'T get in a hurry. The cow has plenty of time and she has to wear the brand the rest of her life. Furthermore, someone will have to read the brand from time to time.
11. DON'T mount your iron on a flat piece of steel. You might as well use a frying pan if you do. If you have your iron made or if you make it yourself, have plenty of air space behind the iron (behind the burning surface). The burning edge should be about 1/8 inch thick.

* Compiled by the Agricultural Extension Service, Tulare County.

Fig. 31 (IV). This cattle chute and squeeze is adapted from what is known as the Nevada low-cost dehorning chute. The body squeeze and neck squeeze operate as in other types of chutes. The distinguishing feature is the absence of a front exit; the animals leave the chute through one side which is hinged and operated as a side gate.

squeeze chute for the dehorning and branding of cattle.

Means for controlling lice, ox warble, flies, and other external parasites should receive attention. Spraying equipment is replacing more expensive dipping vats for most purposes, especially in the use of some of the new insecticides. Information and plans for beef-cattle equipment can be obtained through the Agricultural Extension Service, University of California, Berkeley.

Weighing Cattle. A set of scales is a good ranch investment, not only for use when making sales, but also for weighing the cattle kept on the ranch. Weighing the different classes at the beginning and end of the pasture season, dry season, or winter period gives the stockman a definite basis upon which to plan feeding practices, supplemental feeding, and establish a selling policy. Weights can usually be taken when cattle are brought to the corrals for other purposes. Because of great variations in "shrinks" and "fills," apparent gains or losses over short periods are not very reliable. Cattle should be weighed as nearly as possible under the same conditions each time to obtain reliable data. Steer and heifer weights should always be obtained and recorded separately because of the differences in gains usually made by the two classes. To determine more accurately gains during short periods, weighing after 12 hours (overnight) without feed and water is recommended.

Selling Policy

Cost records over a period of years for the individual ranch, coupled with information on market demand, are the best basis for deciding at what age to market and whether to finish the cattle or to sell them as feeders.

In general, cost-of-production records on breeding ranches show that the total pounds of beef produced from a given amount of feed are greatest where cattle are sold as yearlings. Because of the overhead charge of the breeding herd, calf cost per hundred pounds at weaning time is usually greater than for the same animal a year later. Total ranch production, in the form of two-year-old feeders, is usually less than if all the surplus is sold as yearlings and a larger breeding herd is kept. The price of calves, compared with yearlings and two-year-olds, and of feeders compared with finished cattle in relation to total tonnage of beef produced, must be known to determine the best means of marketing the ranch feed supply.

Practical sorting of cattle before offering them for sale should be a part of the policy whether the animals are sold at home or elsewhere. The wider the variation in quality and weight, the greater the need for sorting. A single buyer is always more attracted to well-sorted loads. If several buyers are in the field, sorting is still more advantageous. The buyer who is seeking a uniform lot of top-quality cattle will discount his bid if inferior animals are included in the offering. On the other hand, the buyer who is satisfied with plain cattle may pay the full market price for that kind, but will pay little, if any, premium for top quality. This same principle applies in sorting according to weight.

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UNIVERSITY OF CALIFORNIA • COLLEGE OF AGRICULTURE
Agricultural Experiment Station and Extension Service

FATTENING CATTLE AND THE DRESSED PRODUCT

Recommended Nutrient Allowances
Fattening Cattle on Pasture
Feed-lot Rations
Creep-feeding of Calves
General Cattle-feeding Problems
Necessary Margin or Spread

Fattening Cattle

Feed-lot fattening accounted for about 15 per cent of the total beef tonnage produced in California in 1942 (table 3, Sec. I). The fattening process is the most expensive stage of production from the standpoint of feed cost per pound of gain, but is essential if one is to capitalize upon the cheaper gains made in the production of feeder cattle. In converting feed into edible products, it is the most efficient stage, because more of the gain is then recovered in edible portion of the carcass and less in inedible offal. During the fattening process, dressing percentage changes from 50 to 55 per cent to 58 to 60 per cent, and occasionally more. This increase in yield, coupled with the added fat necessary to increase tenderness and palatability and to protect the carcass from shrinkage and spoilage during aging, facilitates merchandising and offers a desirable product to the consumer. These are basic reasons for the spread in price between feeder and slaughter cattle—a spread also affected by feed costs and other factors of supply and demand.

Proper adjustment among feeds to be used, cattle to be fed, and feeding practices is of utmost importance in fattening cattle. Points to consider are:

1. Feed, whether raised or purchased, is the greatest item of cost and one over which the feeder can exercise considerable control. For best results, rations should possess: (*a*) quality in each feed, for maximum digestibility; (*b*) balance of feeds, to supply adequate protein, minerals, and vitamins; (*c*) variety, to assure provision of all required nutrients and palatability; and (*d*) economy, to permit profit.

2. On good-quality rations, younger cattle use less feed to produce gain and also make cheaper gains than older cattle. When properly fed, calves require only 65 to 75 per cent, and yearlings 75 to 85 per cent as much feed to produce gain as two-year-olds of the same type and grade fed in a similar manner.

3. To meet Pacific Coast market demands, calves are fattened for 5 to 8 months; yearlings, 3 to 5 months; and two-year-olds, 2 to 4 months. The total gain usually required for finishing calves is 300 to 500 pounds; yearlings, 225 to 350 pounds; and two-year-olds, 125 to 250 pounds.

4. Steers make slightly more gain than

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heifers. Heifers, however, fatten faster than steers. The California market does not demand so high a degree of finish on the heifers; therefore, a shorter feeding period is required for them. Spayed heifers do not gain more economically than open heifers, nor do they excel in dressing percentage.

5. Well-finished heifer calves and yearlings slaughtered at 750 pounds, or less, yield as well as steers of comparable age and grade, and show little, if any, more carcass waste. The carcasses of heavier and older heifers are usually more wasteful than those of steers of similar age and finish. In quality and palatability, heifer beef is equal to steer beef.

6. Feeder cattle of high quality have wider adaptability than those of poor quality. A good general rule is to give most of the best feed to the best cattle.

7. Two- and three-year-old cattle and good-quality early-maturing yearling heifers may fatten on pasture without concentrate supplements. Yearling steers will gain rapidly on good pasture, but will rarely fatten without concentrates. Where it can be practiced, pasture fattening, aided by supplements when necessary, usually results in more economical gains than feed-lot feeding.

8. Creep-feeding is profitable under certain conditions. Well-bred, properly creep-fed calves attain a weight of 700 to 800 pounds and desirable market finish at 10 to 12 months of age.

9. Careful attention to feeding practices is fully as important as right selection of rations and cattle. Proper sorting of the animals, correct preparation of feeds, regularity of feeding, and contentment of the herd often mean the difference between profit and loss.

10. The necessary margin, or spread, between the feeder value and the selling price of the animals when fat, depends largely on the relation among feed prices, cattle prices, and the amount of feed required to produce gain.

Recommended Nutrient Allowances

Tables 10 and 11 (III) give recommended allowances for different weights of fattening calves finished as short yearlings, for yearling cattle, and for two-year-olds.

Expected Gains. The expected gains shown for the different ages of fattening cattle may commonly be obtained with good-quality steers fed from medium- or fleshy-feeder to top-good or choice condition. The indicated gains may be exceeded when consumption of feed or total digestible nutrients exceeds that in the tables, or when the cattle are brought up from thin or medium-feeder condition to a slaughter grade of medium or good. On the other hand, inferior cattle lacking in feed capacity or cattle fed to higher degrees of finish may not make the gains indicated. Both feed consumption and gains vary with the individuality of the cattle, with quality and palatability of feed, with weather conditions, and with management practice. Gains are lower for heifers than for steers of comparable grade and weight.

Feed Capacity. The figures in tables 10 and 11 (III) under "Daily feed, per cent of live weight" and "Daily feed per animal" closely represent the total feed capacity of fattening cattle of various ages, weights, and degrees of fatness. For convenience, this information is given in terms of feed having 90 per cent dry matter, an amount fairly representative of most hays and concentrates. The data have been checked with large-scale feeding operations involving thousands of cattle, and with numerous feeding trials conducted by experiment stations.

Cattle fed for long periods, during which their weights pass through practically the whole range shown for their age class may, under intensive concentrate feeding, reach maximum feed consumption before the end of the period, rather than consume increasing amounts with age as indicated. Under these conditions,

consumption often decreases toward the end of the period.

The practice of marketing cattle by the time they reach this leveling-off stage and before consumption declines should receive due consideration. In California this practice is more widespread than in the Corn Belt, where concentrates are more plentiful and longer feeding periods and higher finish more common. (See also "Minimum Roughage Allowance" in this section.)

Total Digestible Nutrients. The total digestible nutrients (T.D.N.), digestible protein, calcium, and phosphorus requirements in table 10 (III) are given in amounts per day and in table 11 (III) on the basis of required percentages in a mix. The latter can serve as a guide where milled and mixed rations are used; the percentages of feeds in a mix are then controlled at the mixing plant, and the cattle fed according to appetite. Table 23 (V) gives examples of both methods for computing rations and shows how their adequacy can be checked with the recommended allowances.

The recommended total-digestible-nutrient allowances are about minimum for the expected gains shown and for attainment of desirable finish in feeding periods of average length. They are based upon the maximum roughage utilization that is compatible with feed capacity and with digestible-nutrient requirement.

In rations with sufficient roughage to promote normal rumen activity and other digestive processes, the maximum total-digestible-nutrient content is about 75 per cent. Where concentrates are favorably priced, as compared with roughage, one may use rations with higher percentages of total digestible nutrients than the minimum figures shown in the table.

Roughages usually contain 45 to 53 per cent total digestible nutrients on a 90 per cent dry-matter basis, with 50 per cent as a rough average. Similarly, 75 to 80 per cent total digestible nutrients can be taken as the range for commonly used concentrates. On these bases the total digestible nutrients would be 60 to 62 per cent in a ration having 40 per cent concentrates and 60 per cent roughage; 62.5 to 65 per cent in one having 50 per cent each of concentrates and roughage; 65 to 68 per cent in one having 60 per cent concentrates and 40 per cent roughage; and 67.5 to 71 per cent in one having 70 per cent concentrates and 30 per cent roughage.

Minimum Roughage Allowance. To promote normal physiological activity of the gastrointestinal tract, one must feed a certain amount of coarser roughage containing stemmy material or leaves with rough surfaces. Finely ground roughages will not suffice. Apparently both bulk and roughages are involved in bloat prevention.

Food intake is limited on the one hand by the bulk-handling capacity of the intestinal tract; on the other, by the daily digestible-nutrient storage capacity of the animals. Comparison of fattening rations varying in bulk indicates that those containing 70 to 75 per cent concentrates are concentrated enough to permit maximum total-digestible-nutrient intake. More concentrated rations do not appear to result in greater total-digestible-nutrient intake (except possibly for short periods); when they are given, total feed (bulk) capacity is not fully utilized. The recommended minimum allowance for roughage is therefore tentatively set at 0.7 to 0.8 pound (air-dry basis) for each 100 pounds of live weight—the minimum below which some trouble is likely to occur is about 0.5 pound.

Lack of sufficient roughage may partly account for the conspicuous decreases in total feed consumption sometimes noted during the latter part of the fattening period. Deficiency of calcium or of vitamin A is less probable with rations containing the higher levels of roughage, and such rations are consistent with a sound and permanent type of agriculture.

The principle of minimum roughage

applies not only to cattle in feed lots, but also to those on very lush pasturage containing an abundance of leafy, fine-stemmed legumes. Voluntary consumption of about 5 pounds daily of straw by mature animals on such pasture has been observed, the amount varying seasonally with condition of growth, stage of maturity, and botanical composition of the herbage. The addition of dry feed not only helps to prevent bloat, but also tends to counteract excessive laxative effects, increase pasture consumption, and improve the thrift and gains of the animals.

Protein Allowance. In the light of experimental evidence, the allowances in tables 10 and 11 (III) are regarded as the minimum consistent with palatability, necessary food consumption, and expected gains. They are especially recommended when protein feeds are scarce and expensive. Offering a variety of palatable feeds, checking the adequacy of phosphorus supply, and making the rations complete in other respects are especially advisable when minimum levels for fattening rations are used. When protein feeds are plentiful and favorably priced, the protein allowances for fattening cattle may be increased 10 to 20 per cent above the recommended minimum. Protein feeds in excess of these amounts are not recommended, because they are usually higher priced than other concentrates and are no more efficient than grains for fattening. If the excess protein included in many feed-lot rations were used to promote continuous growth of stock cattle and high calf crops in breeding herds, far greater returns would be shown for these valuable feeds.

Calcium and Phosphorus. The requirements given in tables 10 and 11 (III) will be met by most otherwise well-balanced rations. With heavy concentrate feeding of fattening calves and minimum allowance of nonlegume roughage, calcium supplement is required for optimum gain, finish, and bone development. Similarly, rations consisting of alfalfa hay, molasses, and beet pulp (either wet or dry), with little or no grain or concentrate protein feed, require phosphorus supplements. The calcium and phosphorus in feed-lot rations should be checked with the table of requirements. It is just as important to avoid the extra expense and trouble of feeding minerals, when they are not needed, as it is to supply them when they are necessary.

Carotene. Cattle store vitamin A and carotene in the liver and body fat during times of abundant intake from green pasture. The amount stored varies with age and duration of high intake. So long as sufficient storage reserves remain, no dietary source is required. Many rations used in California feed lots contain forage with little or no green color. Grains and by-product feeds are extremely low in carotene or are devoid of it. Carotene deficiency in feed-lot rations is therefore relatively common, and the symptoms are sometimes encountered.

If cattle enter the feed lot with a depleted reserve because of prolonged grazing on dry range, carotene deficiency may occur unless roughage of bright green color is used. In 1934, a striking example of this trouble was found in a herd of 560 head of yearling steers and heifers brought from dry range and fed on bleached hay and straw, cottonseed meal, raisin stems, and barley. After 25 days on this ration, gains were low, the cattle unthrifty, their coats rough, and their eyes watering. Many showed defective vision in twilight, and some were definitely night-blind. The addition of 3 pounds of bright alfalfa hay or lima-bean straw remedied the condition. Within 30 days gains became normal, and the cattle thrifty. Another group—350 head of older animals—brought to the feed lot earlier, showed similar symptoms after 120 days on feed. They also responded to green roughage in the ration.

If it were not for previous storage in the animal and relatively short feeding periods, deficiency symptoms would be

TABLE 23 (V)

EXAMPLES OF ADEQUATE FATTENING RATIONS, ILLUSTRATING COMPUTATION ON THE BASIS OF QUANTITIES OF NUTRIENTS PER STEER DAILY AND ON THE BASIS OF REQUIREMENTS AND NUTRIENTS EXPRESSED AS PERCENTAGES IN THE RATION

	Total feed (dry or equivalent), pounds	Total digestible nutrients, pounds	Digestible protein, pounds	Calcium, grams	Phosphorus, grams	Carotene, milligrams
Fattening calves, weight 600 pounds						
Rations in pounds:						
Alfalfa hay, 3; corn silage, 10; milo, 4.5; barley, 4.5; cottonseed meal, 1	15.9	11.3	1.39	25.4	26.8	120
Oat and vetch hay (bleached), 6; molasses beet pulp, 4; barley, 6; cottonseed meal, 0.5	16.5	11.0	1.37	27.5	21.4	12*
Requirements	16.0	11.0	1.30	20.0	17.0	35
Yearling steers, weight 800 pounds						
Rations in pounds:						
Mixed milled feed (oat and vetch hay, 40 per cent; barley, 35 per cent; molasses, 25 per cent), 15 pounds	15.0	9.25	0.86	22.2	17.5	48
Wet beet pulp, 40 pounds	5.3	3.76	0.44	16.4	2.0	..
Wet brewers' grain, 8 pounds	2.1	1.33	0.37	2.5	4.3	..
Totals	22.4	14.34	1.67	41.1	23.8	48
Requirements	22.0	14.00	1.50	20.0	19.0	45
Yearling steers, weight 800 pounds, mixed milled ration						
Pounds of feed per 100 pounds of mix:						
Oat hay ... 25	....	12.5	0.83	0.07	0.05	200
Alfalfa hay ... 10		5.0	1.05	0.15	0.02	194
Barley ... 30		23.4	2.40	0.01	0.12	...
Molasses dried beet pulp ... 20		14.8	1.06	0.05	0.02	...
Molasses ... 10		5.7	0.02	0.04	0.01	...
Cottonseed meal ... 5		3.7	1.65	0.01	0.05	...
Totals in 100 pounds of mixed feed	....	65.1	7.01	0.33	0.27	394
Requirements per 100 pounds of mixed feed	....	65.0	6.8	0.20	0.19	205
Two-year-old steers, weight 1,000 pounds, mixed milled ration						
Pounds of feed per 100 pounds of mix:						
Alfalfa hay ... 10	....	5.04	1.08	0.150	0.020	194
Oat hay, moderately green ... 40	....	19.20	1.30	0.110	0.090	320
Barley ... 30	....	23.00	2.30	0.001	0.120	...
Milo ... 8	....	6.40	0.66	0.001	0.020	...
Molasses ... 8	....	4.60	0.07	0.020	0.005	....
Cottonseed meal ... 4	....	2.94	1.35	0.010	0.040	....
Totals in 100 pounds of mixed feed	....	61.18	6.76	0.292	0.295	514
Requirements per 100 pounds of mixed feed	....	62.00	6.30	0.16	0.16	210

* The amount of carotene furnished by bleached hay having only a trace of green color may promote normal gains and prevent night blindness, but does not meet recommended allowance for moderate liver storage.

much more common. Data on storage and time for depletion are in Section III. Cattle on rations of cottonseed hulls and meal commonly become vitamin-A deficient in 90 to 120 days. In table 10 (III), the recommended allowance of 6.0 milligrams per 100 pounds of body weight is the minimum amount that will provide for moderate liver storage and thus contribute vitamin A for human food. Optimum feed-lot gains and freedom from clinical symptoms can be assured by as little as 1.5 milligrams per 100 pounds of live weight. One to 3 pounds daily of good green alfalfa hay will meet requirements. Table 13 (III) is a rough guide for estimating the carotene content of feeds from their appearance.

General Feeding Rules. Five rules have proved convenient for rough estimation of rations and for calculating the total feed required for fattening. These are for general guidance only. As a check on balance and adequacy, tables 10, 11, and 12 (III) should be used, along with other data and discussion given under "Nutrient Requirements and Cattle Feeds," Section III.

1. At least three (preferably more) feeds should be included in feed-lot rations.

2. Fattening cattle will consume 2.3 to 3.0 pounds of dry feed, or its equivalent, for each 100 pounds live weight. Generally they will take 3 pounds per hundredweight early in the fattening period and decrease the amount later. Generally in California, the average for the period is close to 2.7 or 2.8 pounds per hundredweight.

3. For rapid gain and finish, calves require at least 68 per cent total digestible nutrients in the ration, or 1½ to 2 pounds of concentrates per 100 pounds live weight. Yearlings require 65 per cent total digestible nutrients in the ration, or 1¼ to 1½ pounds of concentrates per 100 pounds live weight. Two-year-old cattle on good-quality pasture or roughage may, over a longer period, fatten without concentrates; but in the feed lot, for rapid finish, the ration should contain about 62 per cent total digestible nutrients, or 1 to 1½ pounds of concentrates per 100 pounds live weight.

4. When a good legume hay is used as the sole roughage, and the rest of the ration consists of various carbonaceous concentrates, no protein supplement, such as cottonseed meal, is required. When nonlegume roughage is used, 8 to 10 per cent in the mix (or roughly 2 to 2½ pounds per 1,000 pounds live weight) of cottonseed cake, or its equivalent, should be fed.

5. When cattle are fattened on green pasture, no protein supplement is required. On dry pasture containing bur clover, 1 to 2 pounds of cottonseed cake, or its equivalent, for each 1,000 pounds live weight is recommended. On dry pasture with no legumes, the amount of protein concentrate should be increased by feeding 2 to 2½ pounds for each 1,000 pounds live weight.

Fattening Cattle on Pasture

Finishing Yearlings and Two-Year-Olds on the Range. In experiments conducted over the past several years on the San Joaquin Experimental Range, good-grade long-yearling and two-year-old beeves were finished on a range that is poor from the standpoint of fattening cattle. This experience emphasizes the possibilities of finishing a significant proportion of the cattle on the better foothill and valley range so that they will compare favorably with feed-lot cattle. In a more favorable environment, less total concentrate supplement would be required than in the experimental tests.

The conditions necessary to finish long-yearling steers to good slaughter grade are as follows:

1. Maintain the breeding herd in good condition for maximum calf weaning weights and percentage calf crop, as outlined under "Production of Feeder Cattle," Section IV.

2. Breed for fall calves so that as long-yearlings they have had two full green-forage seasons.

3. Supplement calves from weaning time for continuous growth. For best results in finishing, according to data in Bulletin 688 (1) and subsequent tests, a gain of 1 pound or more daily should be obtained during the dry and winter seasons after weaning. About the same amount of concentrates was required whether the cattle were given none after weaning, enough for ½ to ¾ pound gain, or enough for 1 to 1¼ pounds gain. When more of the total feed was used to produce continuous growth, less was required for finishing, and the total weight produced was significantly greater.

4. When range forage becomes abundant and good enough to produce gains, supplemental feeding may be discontinued. Cattle will continue longer to come on call if 3 to 4 pounds of supplement are offered than if less is fed. Often they will cease to come in for a pound of cottonseed cake, or other feed, before the grass alone will produce gains. Apparently they sense whether the feed is worth the effort of a long trip to the supplemental feeding source.

5. One may either allow the cattle to graze without supplement until the feed dries, or start full feeding toward the end of the green-feed season. Tests thus far have shown the latter procedure to be the better. When good green feed is available, gains comparable with those in feed lots are obtained, fattening is more rapid, and less concentrates will be required for 100 pounds of gain.

6. One pound of concentrates for each 100 pounds live weight is about the maximum that can be given safely with once-daily feeding. In hot weather, evening feeding is preferable; the heat produced by this large intake of nutrients at one time is more readily eliminated during the cooler night, and less trouble may be encountered with animals going off feed.

With twice-daily feeding, 1½ pounds or more of concentrates per 100 pounds live weight may be used. The rate of gain and fattening is thereby increased; and so the cattle can be made ready for an earlier market or finished before the range forage deteriorates too much.

7. Cattle to be fattened in this way can be managed best in small fields convenient for feeding, where choice feed, shade, and water are readily obtained. They can be started on concentrates while green feed is still available, if wire-enclosed feeding corrals are constructed near water and the animals are brought in to feed once daily. Later they can be trained to come on call or at sight of the feed truck.

8. Cattle should be in fleshy-feeder to medium-slaughter condition toward the end of the grass season in order to make good-grade beef with a 40- to 90-day full feed. Figure 32 (V) shows the appearance of different groups at the start and finish of the fattening period.

9. Cattle should be started on feed gradually. Use 1 to 2 pounds per head daily until all are eating; then add 1 pound a day until 5 or 6 pounds are consumed. Increase, thereafter, 1 pound per head every 2 to 4 days until 1 pound per 100 pounds live weight is reached. Watch the cattle carefully, and stop the increases or reduce the allowance at the first sign of scouring or going off feed.

10. Surplus heifers can be fattened in this way as yearlings more easily than steers and require less total concentrates.

Two-year-old steers are more easily fattened than yearlings and can be managed as outlined above; but as yearlings they will have received minimum supplements during the dry season to promote gain and prevent loss of flesh.

Table 24 (V) shows data from 9 groups of steers and 2 groups of heifers.

All cattle groups shown in the table had been fed supplements to promote continuous gains after weaning. As yearlings, the two groups later marketed as two-year-olds had also received supplements during the dry-feed and winter period.

Fig. 32 (V). Steers fed for continuous growth and finished on the San Joaquin Experimental Range. *Upper and lower left* show two-year-old steers, group A-38, table 24 (V), at the beginning and end of the finishing period. *Upper and lower right* show long-yearling steers, group A-41-3, at the start of the finishing period and before shipment to market. Both groups produced grade A or good carcasses, corresponding with the 1951 designation of U. S. Choice.

Thus, before finishing began, most of the cattle had weights and condition comparable with those attained by cattle that had not received supplements on the same range a year later.

As the table shows, there were considerable differences in the shipping shrinkage of the various groups. In order that the selling weight might be used as the final weight, and that the picture of actual body-weight increase might be fairly accurate, the full weight at the time feeding began, minus the same percentage shrink that occurred in marketing, was used as the initial weight. The gains so computed were comparable with gains figured on the basis of initial and final shrunk weights on the range (overnight without feed and water) as far as available data permitted comparison.

The grain used for steer groups A-35, A-38, A-36, and A-39, and heifer group A-38 was rolled barley. Groups A-40/1, A-40, A-41/2, and A-41/3 received a mixture of rolled barley, ground grain sorghum, and beet pulp. Steer and heifer groups A-37 were hand-fed fish meal; the molasses was self-fed.

Two-year-old steers that had completed most of their growth were more easily fattened than yearlings on comparable rations, but required more feed for 100 pounds gain.

The concentrate feed required for 100 pounds gain varied for the grain-fed steers from a low of 441 pounds to a high of 725. A rough average might be 600 pounds, an amount comparable with feed-lot concentrate requirements. Range feeding had the advantage of a cheaper roughage than harvested and milled hay.

Finishing of steer groups A-41/2, A-41/3 and heifer group A-38 began while green forage was still available. At this time their gains were more rapid, comparable with feed-lot records, and considerably higher than for groups started after the forage was nearly all dry. Considering that the two A-41 steer groups made good and choice carcass grades, the feed-for-gain relation was also favorable.

Heifers are easier to fatten than steers, but in these tests were not carried beyond the commercial grade.

The lifetime total of concentrates for the two-year-olds, including supplemental feeding after weaning, at the yearling stage, and during the finishing period, was 1,310 to 1,460 pounds. For the year-

TABLE 24 (V)

FINISHING CATTLE ON PASTURE ON THE SAN JOAQUIN EXPERIMENTAL RANGE

Group no.	Year finished	Number in group	Feeding period, days	Average initial weight, pounds*	Average final weight, pounds*	Total gain, pounds	Average daily gain, pounds	Per cent shrink in shipping	Feed used: Cotton-seed cake, pounds	Feed used: Grain, pounds	Feed used: Total concen-trates, pounds	Feed used: Average daily feed, pounds	Feed used: Pounds per 100 pounds gain	Dressing per-centage	Number of head in each carcass grade ‡: AA	A	B	C
Steers (two-year-olds)																		
A-35......	1938	14	49 (May 30–July 18)	1,089	1,141	52	1.06	5 56	134	269	403	8.22	725	58.5	1	13	..	..
A-38	1941	15	75 (May 3–July 27)	1,085	1,184	99	1.32	7.72	153	516	669	8.92	676	59.6	..	15	..	..
Long yearling steers (20–22 months)																		
A-36......	1938	11	69 (May 30–Aug. 7)	769	879	110	1.59	5.38	182	365	547	7.92	497	57.0	..	10	1	..
A-39......	1941	18	104 (May 13–Aug. 25)	763	927	164	1.58	5 31	169	555	724	6.96	441	56.2	..	9	9	..
A-40-1....	1942	8	93 (June 12–Sept. 14)	817	969	152	1.63	6.40	243	779	1,022	11.00	672	59.1	..	5	3	..
A-40......	1942	12	118 (May 19–Sept. 14)	757	957	200	1.69	8.10	261	675	936	7.93	468	58.0	..	7	5	..
A-41-2....	1943	13	100 (May 8–Aug. 16)	696	894	198	1.98	7.93	258	874	1,132	11.32	572	58.9	4	8	..	..
A-41-3....	1943	15	65 (May 8–July 12)	794	931	137	2.11	6.24	152	568	720	11.08	525	59.2	2	13	..	
A-37....	1939	8	89 (May 9–Aug. 6)	800	888	88	0.99	4.92	160†	790†	950	10.67	1,080	55.2	..	..	8	..
Long yearling heifers																		
A-37......	1939	7	47 (May 9–June 25)	703	758	55	1.17	6.42	89†	314†	403	8.57	733	55.3	..	3	3	1
A-38......	1940	10	60 (April 17–June 16)	660	796	136	2.27	6.13	45	267	312	5.2	229	55.8	..	1	9	..

* All final weights are selling weights in San Francisco. Initial weights are full weights, less the same percentage shrink as occurred in marketing.

† Fish meal replaced cottonseed meal, and molasses replaced barley in these trials.

‡ During World War II, under O.P.A., letter grades were used. AA included the old U. S. Prime and Choice; A corresponded approximately to the old U. S. Good; and B and C corresponded to U. S. Commercial and Utility respectively. See description of revised U. S. grades in footnote of table 5 (II), p. 26 of Section II.

ling steers that graded good, the lifetime total was 1,400 to 1,738 pounds. These amounts do not exceed the concentrates commonly required in feed lots for finishing cattle of comparable age. The feed for 100 pounds gain in these trials, and in the ranch trials shown in table 25 (V), can be used in figuring feed costs and necessary margins.

Fattening Cattle on Irrigated Pasture. One of the major problems of California production is the economical finishing of high-quality beef at moderate weights with a minimum use of concentrates.

As table 3 (I) shows, irrigated pastures accounted for an estimated 13 per cent of total beef tonnage in 1942. Irrigated-pasture development has been rapid during recent years and appears likely to continue. The carrying and production capacity, coupled with the saving in labor of harvesting feeds, makes livestock production practicable on relatively high-priced lands. By using irrigated pastures in conjunction, one can utilize the native feed when it is most nutritious and abundant, and can greatly extend the period of continuous growth and development of livestock without resorting to concentrate supplements. Irrigated pastures serve for both growing and fattening cattle.

Proper management of pastures, as well as of livestock, is essential to high production of forage and of beef. Irrigated pasture is discussed in Extension Circular 125 (2). Local up-to-date information on the subject can be obtained from county Agricultural Extension offices. Some important considerations in cattle management may be summarized as follows:

1. The ideal pasture for fattening cattle is a thick sward of fine, leafy, palatable vegetation which is neither too mature nor too lush and watery. Forage of desirable botanical composition, managed so that it can be utilized at the proper growth stage should contain 60 per cent or more of digestible nutrients in the dry matter—a value equivalent to ration composed of about 40 per cent concentrates and 60 per cent hay. Generally for cattle the pasture should contain not more than 50 per cent legumes. Leafy, palatable grasses grown in highly fertile soil and grazed at the proper stage contains more than enough protein and minerals for the needs of the cattle. The nutritional value and physiological effects of good grass may be superior to the legumes, which are frequently responsible for bloat, purgative or laxative effects, and other difficulties. Legumes, however, are an economical means of supplying the large quantities of nitrogen essential to both yield and quality of forage.

2. Building up a higher state of fertility than has generally been realized is essential for high yield of superior quality pasture. Data from areas of the world where pasture production and management are most advanced show that the nitrogen equivalent of 600 to over 1,000 pounds of ammonium nitrate is required annually. This may be acquired through legumes and manuring or, in the case of grass pastures, through chemical fertilization. Phosphorus, sulfur, and/or other elements may be required in specific areas.

Careful adjustment of cattle numbers to forage supply, along with judicious scheduling of irrigation and grazing, is essential to utilization at the proper growth stage for optimum nutritive effect. Concentration of sufficient stock on an area to graze it down evenly and to distribute the urine uniformly requires frequent rotation. This practice affords fresh feed at frequent intervals, which is conducive to higher consumption and avoids radical change in quality due to growth stage. Pasturing before the pasture gets too high not only insures higher nutritive value, but also encourages the grasses to form a thick continuous sward. This probably improves the microclimate at the ground surface and certainly will

TABLE 25 (V)

RESULTS OF RANCH FATTENING TRIALS ON DRY RANGE FORAGE

Cattle	Number of cattle	Average daily ration, pounds	Average initial weight, pounds	Length of period, days	Average daily gain, pounds	Pounds feed for 100 pounds' gain
Two-year-old steers	24	Dry grass-filaree range Barley 3.0 Cottonseed cake 2.0	650	169	1.24	Concentrates 403
Two-year-old steers	97	Dry grass-filaree range Barley 3.3 Beet pulp 2.2 Cold-pressed cottonseed cake 4.3 Grain hay 3.2	808	75	1.54	Concentrates 633 Hay 209
Two-year-old heifers	444	Dry grass-filaree range Barley 4.1 Dried beet pulp 2.3 Cold-pressed cottonseed cake 2.7	733	60	1.32	Concentrates 684
Yearling heifers	250	Dry grass-filaree range Barley 3.6 Dried beet pulp 3.4 Cottonseed cake (43 per cent protein) 1.8	552	87	1.69	Concentrates 523

make the pasture less susceptible to damage by trampling when wet. It's short fine feed that fattens the cattle!

3. On irrigated pasture, bloat is frequently a problem. Its causes are discussed under "Physiological Processes and Cattle Breeding" (Sec. II), and in the paragraphs on "Minimum Roughage Allowance" (V). More detailed information is given in Bulletin 662 (3).

The practical control of bloat depends upon maintaining a suitable mixture of grasses and legumes, as indicated above, and upon meeting the minimum requirement for coarse roughage. Even in the absence of acute bloat, cattle will not do well when the moisture content of the feed is too high and the fiber content too low, as commonly occurs in the late summer and fall. Cattle sometimes scour, lack fill, and graze indifferently on feed that appears excellent. On similar feed other cattle, having access to dry roughage, were well filled and apparently gaining well. In tests of individual cows at this experiment station, more pasture was consumed daily, when the minimum roughage requirement was met by feeding coarse, dry roughage in addition, than when pasture was provided without dry roughage.

4. The fat of cattle on green pasture tends to be more yellow in color than that of cattle on dry rations, because of the abundant carotene. If the carcasses are otherwise desirable and are fat enough to meet grade requirements, the color of fat should not influence the grade. Now that more people realize the value of carotene as a source of vitamin A, there is less prejudice than formerly against yellow fat.

5. The dry matter in pastures may be 55 to 70 per cent digestible. The physical and chemical nature of the feed, however, and the high moisture content, usually keep the intake of total digestible nutrients below the optimum for rapid fattening. Concentrate supplements therefore increase gain, rate of fattening, and the desirability of carcasses of pasture-fed cattle.

6. Green pastures contain enough protein to fatten cattle of all ages. Carbo-

hydrate concentrates, such as grains and by-product feeds, are therefore better adapted, and usually cheaper, as supplements than such protein concentrates as cottonseed cake.

7. The general rules already given for quantity of concentrate supplement and method of feeding on the range (Sec. III) apply to irrigated pasture. Often, however, on such pasture, a longer feeding period can be planned, and less concentrates fed per head daily. The younger the cattle, the higher the proportion of concentrate feed required for rapid fattening.

8. The moist conditions prevalent in irrigated pastures, and the large numbers of animals concentrated on small areas, with consequent frequent regrazing, favor repeated infestation with internal parasites, particularly stomach worms. The symptoms may easily be confused with those produced by immature, watery, laxative forage with too little roughage; and both conditions often are present at the same time. If cattle have rough coats, fail to gain, or lose weight and develop diarrhea, veterinary services should be employed for definite diagnosis. Younger cattle are usually more affected than older ones. The recommended treatment is about 15 grams of phenothiazine for calves, 25 grams for yearlings, and 40 grams for mature cattle. On infested pasture, three to four treatments yearly will usually control the parasites. As a rule, the drug is administered in capsules. Tightly packed ½-ounce, 1-ounce, and 1½-ounce-size capsules approximately furnish the doses recommended above.

If the cattle are not parasitized and do not respond to dry roughage or appropriate change in grazing management, specific deficiencies or the presence of excess molybdenum or other salts should be investigated (see "Nutrient Requirements and Cattle Feeds," Section III).

9. For best results in hot weather, shade should be provided, especially when concentrates are being fed. Artificial shades can be constructed at low cost.

Tests of several kinds of shade at the Imperial Valley Field Station by Kelley and Ittner (4) gave the following significant results:

1. The function of shade is to reduce heat burden induced by direct sun radiation. No shade can appreciably influence air temperature.

2. Shades reduced radiant heat burden by 60 to 65 per cent. At 100° F it was calculated that an unshaded animal must lose a total of 1,344 B.T.U. more heat per hour than a shaded one through vaporization of water. Over a 10-hour period this would require extra vaporization, largely through respiration, of 1.6 gallons of water. This increased load is sufficient to heat 9.2 gallons of ice water to boiling!

3. The best height for the shade is 10 to 12 feet. This cuts off sun radiation and permits good exposure to the cooler sky, yet the shadow does not move so fast that animals have to move frequently to hot ground. The difference in heat load under high (12 feet) and low (6 feet) shades was estimated at 8 to 10 B.T.U. per square foot of exposed body surface. This difference imposed by the low shade during a 10-hour period for an average animal may be calculated as equivalent to the mechanical work of lifting a 2,000-pound weight about 800 feet or the heat equivalent for melting 8 to 10 pounds of ice and heating the water to boiling.

4. Shades covered to a depth of 6 inches or more with straw gave the greatest insulation against radiation. Aluminum shades while new and bright reflected well and were nearly as effective as straw. Galvanized iron was least desirable. It became extremely hot and re-radiated to the cattle, making them visibly less comfortable.

5. For very hot conditions, such as Palo Verde and Imperial valleys, added relief was given by a sub-roof of burlap placed a foot or so above the backs of the cattle

which was kept wet by overhead sprinklers.

Although considerable numbers of cattle are being fattened on irrigated pasture in California, only a little reliable information is available on different pasture mixtures and concentrate supplements. Table 26 (V) includes data from ranch trials on meadow and alfalfa pasture, and from experiment-station trials on alfalfa pasture with and without supplement.

Fattening Cattle on Beet Tops. The yield of beet tops in relation to beet tonnage, the proportion of crown and leaf, the chemical composition, the digestibility, and other characteristics of this feed have been discussed under "Nutrient Requirements and Cattle Feeds" (Section III).

Although much of this valuable feed resource is not recovered by pasturing the scattered tops in the field, this method is most commonly employed.

Two-year-old steers or heifers, long-yearling heifers in fleshy feeder condition, and mature cows are the animals best adapted for finishing on beet-top pasture. Since the feeding period does not usually exceed 90 days, and the gain from beet tops alone varies from 1.0 to 1.5 pounds daily, these classes of cattle are the only ones that can attain satisfactory slaughter condition. Beet-top pastures are also used for growing feeder cattle or for carrying stock cattle during the fall before new range feed becomes available.

Information and recommended procedures may be itemized as follows:

1. To obtain best results from beet-top pasture, one should not allow the cattle to roam at will over a large field. By using temporary cross fences, one can limit their grazing to smaller areas at a time and can move them often to fresh feed. Cattle well along in the fattening stage should not have to graze the fields too closely. After they have salvaged the best of the tops, a follow-up herd of stock cattle or animals early in the fattening stage should be used to clean up the remaining feed.

2. The tops from 1 to 1½ acres of beets yielding 15 to 20 tons per acre will support 1 animal unit for about 90 days.

3. The tops should be allowed to cure for 7 to 10 days before being used as pasture. The grazing area should be limited by fencing so that the feed is utilized, and the cattle should be moved to a new area every 10 to 14 days. Good utilization requires keen judgment; pasturing an area 1 day too long may cost many pounds of gain, and moving 1 day too soon may cost many feed days. Such rotation requires more provision of fencing and water, but gives better results. Furthermore, preparation of the land for the next year is not delayed.

4. Access to hay, dry stubble, or supplementary grain adds needed variety, increases gains, and improves finish.

5. Water loss of cattle on beet tops is high through both feces and urine; and water intake is correspondingly high, especially in hot weather. Adequate drinking water, therefore, must be provided.

6. Cattle on beet tops are subject to choke and bloat caused by hard crowns or small beets lodging in the esophagus. Losses may be heavy, unless the animals are carefully watched, especially toward the end of the forenoon and evening grazing periods. If found in time, the lodged crown or the beet can be removed or pushed on down the esophagus with a well-lubricated heavy rubber hose.

7. In a controlled test, steers ate approximately 60 per cent crown and 40 per cent leaf, when allowed free choice, whereas the percentage yield weight of crown was 40 per cent, and of leaf 60 per cent. Discarding of leaf is commonly noted among cattle pasturing tops. These data indicate the loss of feed value that occurs from selective grazing, trampling, and the like, in pasturing scattered tops. Piling tops by hand, or bunching and windrowing them with harvesting machinery, would materially reduce loss and

TABLE 26 (V)

RESULTS OF SUPPLEMENTING GREEN PASTURE FOR FATTENING CATTLE*

Cattle	Number of cattle	Average daily ration, pounds	Average initial weight, pounds	Length of period, days	Average daily gain, pounds	Pounds feed for 100 pounds' gain
Yearling steers	48	Partially irrigated meadow† ... Barley 3.9 Raisins 3.3 Cottonseed cake 1.1 Alfalfa 5.1	495	130	1.61	Concentrates 514 Hay 319
Yearling heifers	79	Partially irrigated meadow ... Barley 3.5 Raisins 3.1 Cottonseed cake 1.0 Alfalfa 3.4	430	113	1.51	Concentrates 505 Hay 227
Steer calves	24	Alfalfa pasture alone ...	459	89	1.39	...
Steer calves	24	Alfalfa pasture ... Barley 8.4	584	105	1.95	Concentrates 429
Yearling steers	36	Alfalfa pasture alone ...	615	89	1.41	...
Yearling steers	36	Alfalfa pasture ... Barley 8.5	743	105	2.02	Concentrates 412
Yearling steers	254	Alfalfa pasture ... Barley 5.4 Alfalfa hay 10.2	673	124	1.50	Concentrates 358 Hay 672

* The different lots of cattle varied in type, quality, and market grades as feeders. Final slaughter grades were "medium to good" and "good."
† Pasture dry the last 30 days.

TABLE 27 (V)

Ranch Tests with Fattening Cattle on Beet Tops

Number and class of cattle	Period on feed, days	Area pastured, acres	Yield of beets, tons	Average daily gain, pounds	Beef produced per acre, pounds
781 two-year-old steers	82	830	16.6	1.43	91
451 two-year-old steers	94	...	12.0	1.06	...
127 two-year-old steers and heifers	94	135	16.0	1.30	116
55 two-year-old steers	60*	57	14.0	1.56	91

* Beet tops not completely utilized.

increase beef production per acre. Optimum utilization, however, depends upon harvesting the dried tops, or making beet-top silage and including it with other feeds in a well-balanced ration. Information on such methods appears under "Feed-lot Rations," which follows.

Table 27 (V) presents the results of several ranch trials with cattle on beet-top pasture.

Feed-lot Rations

Both farmers and commercial feeders in California have several alternatives when planning rations for feed-lot fattening. The farmer who uses cattle primarily to market his ranch feeds can often plan his crop program to produce feeds that will combine in a satisfactory fattening ration without the aid of any purchased supplements.

The total tonnage of digestible nutrients from alfalfa hay, grain hay, and threshed grains that is available to be marketed through cattle in California exceeds that from all other harvested feeds and by-products combined. These feeds, therefore, are the basis of most feed-lot rations. Important points to be considered in using hay and grain are as follows:

1. The higher the quality of roughage, the greater its digestibility, and therefore less concentrates are required to bring the ration up to the minimum total-digestible-nutrient requirements in tables 10 and 11 (III). Careful curing of roughages harvested at the best stage of growth for maximum yield of digestible nutrients, therefore, can significantly reduce concentrate requirements for fattening. On the other hand, one can depend almost entirely for digestible nutrients on the concentrates, feeding limited roughage largely to supply bulk. (See "Minimum Roughage Allowance" in this section.) Low-grade roughage can be and is commonly used in this way by large commercial operators, who depend on buying cheaply these low-grade hays and straws. When maximum concentrates are fed, roughage supplies only a small percentage of the total digestible nutrients; and variation of 40 to 50 per cent total digestible nutrients in the roughage causes only small variation in their percentage in the ration. For this reason extensive feeders commonly say that if cattle receive enough concentrates, any kind of roughage can serve for bulk. Since, however, roughages are depended on not only for bulk and total digestible nutrients but also for much calcium, phosphorus, carotene, and protein, quality of roughage should be a primary consideration, especially with farmer feeders.

2. A ration composed solely of a full feed of barley and alfalfa hay can meet nutritive requirements and produce excellent gains and finish. One must, however, watch for digestive disturbances and bloat. As stated in "General Feeding Rules" in this section, a combination of three or more feeds is preferable. When equal parts of cereal and alfalfa hay are fed, the cattle go on feed faster, and there is less tendency for digestive upsets, going off feed, scouring, severe coccidiosis, and

the like, than when alfalfa hay is used alone, particularly if the hay is very fine and leafy.

3. A combination of two or more grains is always preferable to a single grain. Milo alone is somewhat superior to barley alone. For best results, wheat should not form over 50 per cent of the concentrate ration.

4. The proportion of hay to grain will depend upon the age class and the quality of cattle, and upon the costs of hay and grain in relation to their productive feed values. The rations, however, should contain not less than the minimum percentages of total digestible nutrients shown in tables 10 and 11 (III). When making up rations, these tables in Section III, "Nutrient Requirements and Cattle Feeds," and the general feeding rules on page 6 (V) should be consulted.

Grain and hay rations can often be made more efficient and economical by the addition of palatable feeds other than protein concentrates. Recommendations for the use of several other feeds in replacing a portion of the grain or hay, especially in feed-lot fattening, are now presented.

Silage. The advisability of using silage in cattle fattening depends on the character and prices of the feeds to be replaced, the yield and cost of the silage per acre, and the probable returns from other crops that might be grown instead.

Numerous tests have shown that silage will usually improve grain-and-hay rations, particularly those lacking variety. When silage is added to a barley and alfalfa ration, bloat rarely occurs. Rations that already possess quality, variety, and balance may be made more economical by the use of good-quality silage to replace more expensive feeds. When cattle are given a full feed of concentrates, corn silage, and alfalfa hay, the feed-replacement value of the silage per ton may be more than half that of the hay as shown by the following examples: An average of five trials at the Idaho Station gives the results of adding corn silage to long alfalfa hay and barley for fattening steers weighing 896 pounds at the start and fed an average of 137 days. The alfalfa-barley lots ate 25.5 pounds of hay and 8.89 pounds of barley per head daily. Their daily gain averaged 1.72 pounds; their shrinkage to market, 3.6 per cent; and their carcass yield, 60.2 per cent. The silage-fed lots consumed daily 19.3 pounds hay, 18.5 pounds silage, and 8.76 pounds barley, and made an average daily gain of 1.90 pounds. Their shrinkage to market was 4.2 per cent, and their carcass yield, 60.6 per cent. In these five trials each ton of silage replaced 964 pounds of long alfalfa hay and 115 pounds of ground barley. One California stockman, coöperating with the Agricultural Extension Service, conducted a 106-day trial wherein 170 head of two-year-old steers were fed daily per head an average of 13.7 pounds of corn silage, 14.6 pounds of mixed alfalfa and grain hay, and 9.3 pounds of a mixture of barley, molasses, and cottonseed meal. An equal number of steers comparable in grade and weight received 17.3 pounds of the hay and 11.3 pounds of the concentrates per head daily, but no silage. In this trial, 1 ton of silage replaced 217 pounds barley, 221 pounds molasses, 72 pounds cottonseed meal, 345 pounds alfalfa, and 231 pounds grain hay. The average yield and carcass grade of the two lots were about the same.

Good-quality corn silage added to a ration consisting of legume hay alone will increase the rate of gain and may show a value per ton equal to the hay. In rations composed of grain, hay, and silage, the silage is fed at the rate of 1.5 to 3 pounds per 100 pounds live weight.

In California, corn and sorghums for silage are ordinarily produced under irrigation. Yields of from 15 to 20 tons are not uncommon on good land. The value of the trench silo as an inexpensive and satisfactory means of storing silage has been fully demonstrated (fig. 33, V). Cost-of-production studies show that corn

Fig. 33 (V). In this trench silo, corn yielding 60 bushels of grain and 18 tons silage per acre was stored with practically no loss from spoilage. When the silage was fed to yearling steers in a daily ration at the rate of 14.7 pounds per head, along with 5.3 pounds grain and 8.7 pounds alfalfa hay, the cattle made a net daily gain of 2.33 pounds per head.

silage represents fully as high a use of land as alfalfa when it can be fed near where it is produced.

The value of corn silage varies considerably with the amount of grain it includes. Grain yield depends somewhat on the strain of corn or sorghum used. Hybrid seed corn, giving high grain yield, can significantly increase silage value and decrease other grain required in the ration. Significant amounts of grain from sorghum silage pass through cattle undigested. The possibility of reducing this loss is suggested by experiments at the Kansas Agricultural Experiment Station. A combination knife-hammer mill was used with a regular silage cutter. Atlas sorghum was topped at the silo; the heads were finely ground in the combination mill and dropped on the feed table of the cutter. The combined ground heads and cut forage were blown into the silo. A feeding test showed 12 per cent more gain from a ton of this silage than from the same feed run through the cutter only.

Wet Beet Pulp. Most of the wet beet pulp in California has been utilized by a few commercial feeders, located near sugar factories, who are prepared to handle large tonnages of pulp with little transportation. Recently this product has been more widely distributed among farmer feeders in the beet-growing districts relatively near the sugar factories.

Wet beet pulp is bulky and is palatable to cattle. The dry matter is composed mainly of carbohydrates, and the fiber is highly digestible. Wet pulp is deficient in both protein and phosphorus; but, if provision is made to offset the deficiency, and the price is right, this feed can often improve the effectiveness and economy of grain-and-hay rations. When the feed lot is located near the source of supply, wet pulp in its various forms, fresh, siloed, or pressed, may be a cheap feed. Because of its high moisture content, it cannot economically be transported far. The wide variation in moisture content greatly affects its value per ton. Fresh pulp, which may contain as little as 5 per cent dry matter, is obviously worth far less than siloed or pressed pulp containing 13 to 15 per cent. Cattle usually prefer well-fermented siloed pulp to the fresh product. Even if the silo is large, loss from shrinkage commonly amounts to 40 per cent of the dry matter, because of fermentation and oxidation. Possibilities of reducing these losses, inducing a better type of fermentation and producing a silage with a more pleasant odor through the addition of molasses or, still better, barley or other grain, providing leaching by rain is prevented, has been shown by Guilbert, Miller, and Goss (5).

Cattle take readily to wet pulp. When fully accustomed to it and given all they will eat, if little or no concentrate is used in the ration, they may consume up to 8 to 10 pounds per 100 pounds animal weight.

In an average of four feeding trials at the Colorado Agricultural Experiment Station, siloed wet pulp added to a ration of barley, cottonseed cake, and alfalfa hay increased the gain, the selling price, the dressing percentage, and the carcass grade of fattening calves. Each ton of wet pulp replaced 142 pounds barley, 2.7 pounds cottonseed cake, and 342 pounds alfalfa hay. Tests at the Utah Agricultural Experiment Station have well demonstrated the possibilities of overcoming the phosphorus deficiency in beet pulp by the addition of a small amount of steamed bone meal. In these tests feeding of 0.1 pound per head daily of steamed bone meal to cattle receiving a ration of wet beet pulp, molasses, and alfalfa hay increased the feed consumption, doubled the rate of gain, and materially reduced the cost of gain. Under these conditions the alfalfa hay supplied adequate protein.

Siloed pulp, fresh-pressed pulp, and dried molasses beet pulp were compared in two ranch feed-lot trials near Woodland. When both trials were averaged, there was no significant difference in rate of gain between the lots receiving dried pulp and those securing siloed pulp. The latter lots, however, required less dry matter for 100 pounds of gain. Tests at the Colorado Station showed dried pulp to have about 90 per cent of the value of equivalent dry matter in siloed pulp—a value in substantial agreement with the results at Woodland. In both trials the rate of gain was slightly less on fresh-pressed than on siloed pulp, and the dry matter of the latter appeared to be somewhat more efficiently utilized.

Dried Molasses Beet Pulp. Where used to replace not more than half of the grains in a grain-and-hay ration or in feeding concentrates on pasture, dried molasses beet pulp has a feeding value about equal to barley. It is very palatable, helps to get cattle on feed quickly, and decreases digestive disturbances.

Beet Tops. As shown under "Nutrient Requirements and Cattle Feeds," Section III, beet tops are a valuable replacement for part of the concentrates as well as part of the roughage in a fattening ration. Because of the high mineral content and laxative effect, best results are obtained when limited amounts are fed. For yearling steers weighing about 700 pounds, a good ration would be grain 8 to 10 pounds, alfalfa hay 6 pounds, and beet-top dry matter 6 pounds (equivalent to about 9 pounds of dried tops or 20 pounds of beet-top silage). For half the grain, one might substitute either the same weight of dried beet pulp, or 40 to 45 pounds of wet pulp. The addition of 0.1 pound daily of ground limestone (calcium carbonate) to counteract oxalic acid and minimize scouring has been recommended by the Colorado Experiment Station. Fed in this way, beet tops have produced up to 250 pounds of beef per acre, or more than double that obtained by pasturing.

Raisins and Prunes. In years of surplus raisin crops, large amounts are used in livestock feed; they are satisfactory in cattle fattening, to replace not more than 40 per cent of the grain. In one ranch feeding trial in Tulare County, raisins and dried molasses beet pulp were compared in fattening rations for two lots of 50 yearling steers each. The feeding period was 111 days. Good-quality muscat raisins, including very few stems, were used at the rate of 2.6 pounds daily to replace an equal amount of pulp. In addition, each lot of steers ate 3.4 pounds of barley and 17.5 pounds of alfalfa hay per head daily. The rate of gain and the feed required to produce gain were slightly in favor of the raisin-fed lot, but the difference in this respect was not significant. When an effort was made to increase the raisins beyond 40 per cent of the total concentrates, some were left in the trough. Other ranch feeders report similar results.

Raisins available for livestock feed are

apt to vary more in quality than a product like dried beet pulp. In years of fair price for raisins very little, if any, of the better grades will go for livestock feed. Some lots of raisins contain numerous stems, which decrease the feeding value. Wire and nails are sometimes present and may cause serious trouble if swallowed.

Dried prunes may be used in the same way as raisins. They can be ground in a hammer mill along with barley or other grain to make more available the nutritive value in the pits. Ten to 15 per cent prunes ground with 85 to 90 per cent barley go through the mill satisfactorily.

Dried Orange Pulp. This product has total digestible nutrients equivalent to barley and is fairly palatable. Feeding experiences in California indicate that it should be fed only in limited amounts if its greatest value is to be obtained. Dried orange pulp and other citrus pulps were used to replace 25 to 45 per cent of corn in fattening rations at the Texas Station. When fed in these proportions, they produced results equal to corn.

Cane and Beet Molasses. According to total digestible nutrients, cane and beet molasses are about equal, and have three fourths the feeding value of barley (table 12, III). In cattle-fattening rations the greatest returns from molasses are obtained when it is added to rations lacking in palatability. When used in small quantities, molasses may show a feed replacement value equal to barley. In excess of 25 per cent of the grain ration, the value falls to three fourths that of barley. Molasses is commonly used in cut mixtures, on wet beet pulp, and often is sprinkled or sprayed over long hay. Hay that has been through a hammer mill needs an admixture of molasses to reduce dust and facilitate handling. Molasses stimulates the activity of the rumen microörganisms—a fact that explains part of its beneficial effects. By providing readily available sugar for these microörganisms it discourages their action on cellulose, and somewhat reduces crude-fiber digestion. Thus molasses may reduce the digestibility of straw; but this effect will be more than offset by the greater quantity consumed by the animals. The characteristics of molasses and recommendations for mixing it with other feeds are further discussed under "Nutrient Requirements and Cattle Feeds," Section III.

Roots and Tubers. Cull potatoes, sugar beets, carrots, and other roots and tubers can often be used efficiently with other feeds in cattle fattening. High in moisture content, such products cannot be economically transported far. They give best results when fed in limited quantities to add succulence and palatability to grain-and-hay rations, especially in cattle fattening.

In one Idaho Agricultural Experiment Station trial, potatoes and corn silage were compared as supplements with alfalfa and barley for fattening. The steers were fed for 159 days, and their average weight for the period was about 1,030 pounds. The potatoes were used at the rate of 16.9 pounds daily, or about 1.5 pounds per 100 pounds weight of the steers. In this trial the potatoes had a feed-replacement value about equal to that of corn silage. In two trials at the Colorado Station, potatoes and corn silage were compared in calf-fattening rations in which the other feeds were barley, cottonseed meal, and alfalfa hay. The calves were fed for 194 days and averaged, for the period, about 610 pounds in weight. The potatoes were fed at the rate of 16.4 pounds, or about 2.7 for each 100 pounds weight of the calves. In the Colorado trials the potatoes, fed in relatively heavy amounts, were worth much less than corn silage.

Potatoes can be successfully ensiled, but it is better to mix them with some dry feed. In the Colorado trials, a silage composed of 82 per cent cull potatoes and 18 per cent corn fodder was about equal to corn silage in the fattening ration of calves.

Dried potato meal can replace about

50 per cent of the concentrate ration for fattening cattle. Since it contains less than half as much digestible protein as barley, protein concentrate allowance must be correspondingly increased. Conservation and utilization of root crops are discussed under "Nutrient Requirements and Cattle Feeds," Section III.

Brewers' and Distillers' Grains. Wet brewers' grains and distillers' grains contain 75 to 80 per cent moisture and distillery slop 93 to 96 per cent moisture. These products should be fed fresh to avoid danger of spoilage. Their economic use is therefore confined to feed-lot operations located near the brewery or distillery. Ordinarily these feeds are used in fattening the lower grades of mature cattle, and maximum amounts are fed. A 1,000-pound animal may consume 40 to 50 pounds of wet brewers' grains containing about 10 to 12 pounds of dry matter; or up to 200 pounds of distillery slop, containing about the same amount. To meet the additional dry-matter requirements, one should feed dry roughage and some grain or other carbonaceous concentrate. Since the dry matter of wet grains is 20 to over 25 per cent digestible protein, protein supplements are not necessary. For best results and most efficient utilization of these feeds, especially distillery slop, the quantity fed should be limited. Cheapness of the slop has encouraged maximum feeding; but, as a rule, gains are then considerably less than with usual feed-lot rations. For 1,000-pound steers, a ration consisting of 2 to 4 pounds of grain, 2 to 4 pounds of molasses, 10 to 12 pounds of hay, and 16 to 20 gallons (130 to 160 pounds) of slop has proved satisfactory. The hay should contain enough green color to assure a carotene content that is adequate for preventing vitamin-A deficiency. For younger cattle reduce the slop and increase the grain.

Rough Rice. Ground rough rice is palatable to cattle and satisfactory for use in combination with grain and hay rations. In a trial at the Missouri Agricultural Experiment Station it was fed to yearling steers at the rate of 13.1 pounds daily to replace a like amount of shelled corn. Other feeds in the ration were cottonseed meal and soybean hay. The rice proved highly palatable; and in this trial, where it was fed as the only grain, it was worth 76 per cent as much as shelled corn.

Straw. When hay is high priced and straw is cheap and abundant, the latter may be used efficiently in fattening rations if fed in limited amounts. The feeding value of each kind of straw differs according to stage of maturity when cut and amount of grain or seed included.

In general, grain straws are worth about half as much as alfalfa hay. They are low in productive value, protein, and palatability, and are high in fiber content. In feeding value, the common California grain straws usually rank as follows: oat, barley, and wheat.

Ordinary field-bean straw is coarse and fibrous. The feeding value does not differ greatly from that of grain straw unless a great number of the beans are included.

Lima-bean straw is the best kind ordinarily available in California. It is usually leafy and palatable. In feeding value it is about equal to good grain hay, when fed in combination with other good-quality roughage.

Small amounts of pea straw and alfalfa straw are available for livestock feeding. These are usually intermediate in value between lima-bean and grain straw.

For best results in fattening, straw from grains and field beans should be limited to 25 to 30 per cent of the total roughage. Lima-bean straw can satisfactorily constitute half of the total roughage.

Examples of adequate rations computed from the data in table 12 (III) on feed composition appear in table 23 (V), along with the requirements shown in tables 10 and 11 (III). The first section of table 23 (V) shows rations for fattening calves and yearlings, together with the amounts of nutrients furnished daily. The second section gives sample rations for

yearling and two-year-old steers; shows the nutrients furnished; and specifies the requirements, computed on the basis of percentages.

The results of numerous California feeding tests and of ranch feeding records are presented in table 28 (V). These may be used in computing fattening costs and necessary margins.

Creep-feeding of Calves

Under certain conditions in California, the creep-feeding of calves continues to grow in use and popularity. In this practice, young calves are allowed access to extra feed while they are still nursing. The feed is placed in a self-feeder, trough, or rack within a small enclosure. In the fence are openings through which the calves may enter but which are too small for the cows. Calves that will be fattened and slaughtered young are often creep-fed to induce faster finish and shorten the feeding period after weaning. Well-bred calves when properly creep-fed attain a weight of 700 to 800 pounds and a desirable market finish at 10 to 12 months of age. Such calves may not gain so well in the feed lot after weaning, as calves that receive no grain during their nursing period. When calves are creep-fed from a few weeks of age, however, the total feed required to fatten them is usually less than if they are not fed until after weaning. Creep-feeding during the nursing period produces more uniform calves. Calves from heifers and inferior milking cows usually eat more from the feeder than the others do. When natural feed conditions are unfavorable, creep-feeding indirectly helps the cows, for the calves then draw less heavily upon them during the latter part of the nursing period.

Good breeding in cattle is desirable in all feeding operations; but in creep-feeding for market finish, the well-bred calf of good quality is essential. The sires should be superior purebred Hereford, Shorthorn, or Angus bulls. The cows should be above average range quality.

Creep-feeding is adapted to pastures and ranges where the herd comes regularly to a central point for water, salt, shade, or rest. Such ranges must be accessible by truck. The method is *impractical* on rough hilly ranges, or on any range where cattle graze over vast areas and infrequently gather at a central point, or where transportation of feed is difficult.

Best results have been obtained with so-called "early calves," which are started on feed before they are 3 months of age. Such calves are dropped before the green-grass season. They learn to eat grain early, take full advantage of a heavy milk flow from the cows while the grass is good, and by the time the grass is dried are ready to consume comparatively large amounts of grain. Calves will learn to eat grain at 4 to 6 weeks of age. When the creep is constructed near the watering place, salt grounds, corral, or loafing ground of the herd, almost immediately some calves will enter it through curiosity; and, after these few calves have started to eat, nearly all the others will follow their example.

Early in the creep-feeding period, the ration should contain a variety of good-quality grains or grain substitutes. When the calf is young, the grass green, and the cow's milk abundant, protein supplements are not necessary. After the grass is dry and the milk is decreased, one part pea-sized cottonseed cake or meal may well be added to every 10 to 12 pounds of carbonaceous feeds. If fish meal is substituted for cottonseed cake or meal, about one third less is required to provide the necessary protein. Linseed meal or soybean meal may substitute for cottonseed meal pound for pound. If the cows and calves are on good-quality pasture, hay is usually not provided in the creep-feeder. When grazing conditions are poor and forage is of low quality or scarce, good alfalfa meal or alfalfa-molasses meal will be of material benefit when added to the concentrate mixture in the self-feeder. High-quality long alfalfa hay may

TABLE 28 (V)

RESULTS WITH FEED-LOT RATIONS IN CALIFORNIA EXPERIMENT STATION AND RANCH TRIALS*

Cattle	Number of cattle	Average daily ration, pounds	Average initial weight, pounds	Length of period, days	Average daily gain, pounds	Pounds feed for 100 pounds' gain
Steer calves	12	Alfalfa 7.3 Barley 9.6	413	210	2.11	Concentrates 454 Hay 346
Steer calves	12	Alfalfa 6.9 Barley 9.1 Cottonseed meal 1.0	414	210	2.15	Concentrates 466 Hay 318
Steer calves	12	Corn silage 11.9 Alfalfa 3.0 Rolled barley 8.7 Cottonseed meal 1.0	417	210	2.18	Concentrates 445 Silage 543 Hay 137
Yearling steers	10	Alfalfa 8.9 Barley 10.4	605	114	2.15	Concentrates 481 Hay 413
Yearling steers	10	Alfalfa 13.2 Barley 6.8	591	121	1.91	Concentrates 354 Hay 691
Yearling steers	10	Cottonseed hulls 18.8 Cottonseed meal 7.7†	612	112	2.11	Concentrates 362 Hulls 891
Yearling steers	10	Alfalfa 10.9 Barley 8.3	557	150	1.99	Concentrates 419 Hay 550
Yearling steers	10	Wild oat hay 9.9 Barley 7.0 Cottonseed meal 1.8	557	150	2.03	Concentrates 434 Hay 485
Yearling steers	10	Wild oat hay 11.6 Barley 4.0 Cottonseed meal 2.0 Molasses 2.9	557	150	1.92	Concentrates 462 Hay 605
Yearling steers	15	Alfalfa 8.2 Barley 5.2 Dried molasses beet pulp 6.3 Cottonseed meal 0.3	649	158	1.85	Concentrates 636 Hay 442

Yearling steers	14	Alfalfa 8.1 Barley 5.3 Molasses 1.8 Siloed beet pulp 39.0 Cottonseed meal 0.24	646	147	2.08	Concentrates 348 Beet pulp 1,869 Hay 388
Yearling steers	50	Alfalfa 17.4 Barley 3.4 Dried beet pulp 2.6	566	111	2.22	Concentrates 270 Hay 781
Yearling steers	50	Alfalfa 17.6 Barley 3.4 Raisins 2.6	562	111	2.31	Concentrates 258 Hay 761
Short-yearling steers	42	Alfalfa 8.7 Corn silage 14.7 Corn and cob meal 5.3	462	134	2.33	Concentrates 227 Silage 373 Hay 633
Yearling heifers	12	Alfalfa plus 20 per cent molasses 10.3 Concentrate mixture: Barley 50 per cent Dried beet pulp 40 per cent Cottonseed meal 10 per cent 8.6	573	118	1.85	Concentrate mixture 467 Alfalfa-molasses meal 556
Yearling heifers	305	Ground mixed hay 13.7 Corn silage 9.0 Barley 4.8 Molasses 2.6 Cottonseed meal 1.6	578	72	2.06	Concentrates 435 Silage 435 Hay 661
Two-year-old steers, "tail enders"‡	170	Ground alfalfa 10.2 Ground grain hay 7.1 Barley 5.9 Molasses 3.4 Cottonseed meal 2.0	791	106	1.49	Concentrates 762 Roughage 1,167

* The different lots of cattle varied in type, quality, and market grade as feeders. Most lots attained "good" or "good to choice" slaughter grades and yielded 57 to 60 per cent. Very little feed was wasted or unaccounted for.

† Vitamin-A deficiency occurred at the end of 112 days and was cured by alfalfa feeding.

‡ Cattle left after several times "topping" the better-gaining cattle.

also be fed in a separate rack alongside the self-feeder. When silage is near at hand, it may be found practical and beneficial during the creep-feeding period, especially when grass or dry roughage consumed is of poor quality.

In creep-feeding calves for the first time, stockmen are apt to grow impatient at the seemingly slow progress made for the first 2 or 3 months; by this time, however, the results become more evident.

Experience has shown that where calves are being finished for market, the self-feeder is usually more practical to use than hand-feeding in trough.* The openings in the creep fence should be made for the calves to walk through. Sometimes a fence is constructed to permit the calves to crawl under, but this practice is not so satisfactory. Rarely will any trouble from overeating be experienced in self-feeding if the calves have been taught to eat grain at 2 to 3 months of age. When feeding is delayed until later, difficulty from overeating may result if self-feeders are used. When the calves are weaned and brought into the feed lot, the same self-feeder can be moved into the lot.

Weaning creep-fed calves is a simple matter. The calves are advanced enough in the feeding period so that they do not miss their mothers, and if they are continued on feed without radical change in the ration, no setback is experienced. Stockmen have been surprised to see how these calves maintain their "milk-fat" bloom after weaning.

Creep-feeding of calves on the range is a means of stabilizing weaning weights in the same way that supplemental feeding of breeding herds stabilizes percentage calf crop with forage conditions varying from year to year.

The results of fattening several different lots of calves which were creep-fed before weaning are summarized in table 29 (V).

* Plans for the construction of a calf creep and self-feeder are available from the Agricultural Extension Service, University of California, Berkeley, California.

General Cattle-feeding Problems

Age of Cattle. After maintenance requirements are met, young cattle can use feed for both growth and fattening, whereas the mature animals' use of the ration above maintenance is confined to the production of fat. For this reason calves fed on complete rations, possessing quality, variety, and balance, produce more economical gains than yearlings, which in turn make cheaper gains than two-year-olds. Since young cattle require more concentrates, less roughage, and higher-quality feeds, the older cattle are better adapted for fattening when large amounts of coarse bulky roughages are to be utilized. Two- and three-year-old steers, for example, are often fattened on pasture or beet tops without concentrates, or may be fairly well finished in the feed lot on hay alone or such rations as hay and silage. Roughage rations alone will not fatten calves or yearling steers. If such rations are of good quality, yearling steers will make satisfactory gains on them, but mostly in the form of growth. Well-bred yearling heifers with early-maturing tendencies sometimes fatten without concentrates if the roughage or pasture is good and relatively high in digestibility.

Since two-year-old cattle need less of their feed for growth, the fattening period required is only about half as long as for calves. Sometimes conditions warrant limited feeding, and the time for each class is accordingly increased.

The younger the animals, the greater is the attention necessary to details of feeding. Calves are unusually susceptible to irregular feeding practices and to muddy feed lots.

Superior type, high quality, and desirable conformation are essentials in fattening calves. Plain and rough animals do not finish readily at this age, although they make good gains. Such animals had better be held for fattening later on.

The time for marketing calves and yearlings is more flexible than that for two-

TABLE 29 (V)

RESULTS OF FINISHING CALVES WHICH HAD BEEN CREEP-FED DURING THE NURSING PERIOD*

Animals fed	Average daily ration, pounds		Average initial weight, pounds†	Average daily gain, pounds	Pounds feed consumed per 100 pounds' gain
61 steers and 34 heifers fed together both periods	Creep-feeding period of 193 days	Concentrates 3.1	...	....	...
		Silage (48 days) 5.0	...	....	...
	Feed-lot period (after weaning) of 133 days	Concentrates 12.1	480	2.16	Concentrates 559
		Hay 3.6			Hay 165
		Silage 7.2			Silage 338
39 steers and 39 heifers fed separately in feed-lot period	Creep-feeding period of 109 days	Concentrates 2.3	...	....	...
	For steers, feed-lot period (after weaning) of 175 days	Concentrates 10.3	332	1.95	Concentrates 524
		Hay 6.4			Hay 327
	For heifers, feed-lot period (after weaning) of 180 days	Concentrates 9.9	314	1.83	Concentrates 541
		Hay 6.1			Hay 331
39 steers and 26 heifers fed separately in feed-lot period	Creep-feeding period of 115 days	Concentrates 2.2	...	....	...
		Silage (55 days) 5.8	...	....	...
	For steers, feed-lot period (after weaning) of 202 days	Concentrates 8.1	398	1.63	Concentrates 496
		Hay 7.2			Hay 444
	For heifers, feed-lot period (after weaning) of 184 days	Concentrates 7.3	375	1.51	Concentrates 484
		Hay 6.6			Hay 432

* Agricultural Extension Service (Ventura County) summarized report of creep-feeding demonstration on Rancho Matilija, Ojai, Calif. 1935.
† No weights obtained at start of creep-feeding period.

year-olds. If current market conditions are unfavorable, calves or yearlings may be held for several additional weeks or even months and continue to make efficient gains. Two-year-olds have a much narrower time limit for producing economical gains.

Sex. The average calf crop is about equally divided between steers and heifers. Over a period of years about half the heifers—theoretically the best ones—are retained for breeding-herd replacements. This means that about 25 per cent of the annual output from breeding herds is composed of heifers that compete directly with steers in the feeder- and slaughter-cattle market. Usually a substantial price spread exists between steers and heifers, both as feeders and when the animals are ready for slaughter. In years when cattle numbers are expanding, there is a tendency to hold back more heifers for breeding; supplies of all slaughter cattle are usually lighter, and the spread in price between steers and heifers is less than in periods of overproduction, when a greater percentage of heifers and cows is offered for market.

For years, prejudice has existed in the markets against heifers, based largely on the danger of their being pregnant and the claim that heifers produce more wasteful carcasses than steers. To overcome the objection to bred heifers and to permit running of market heifers with the general herd, some producers have followed the practice of spaying. The criticism that heifer carcasses are wasteful is somewhat reduced with the trend toward marketing more of them as yearlings and calves.

Numerous tests have been conducted at state experiment stations to determine the extent of justification for discriminating against feeder and slaughter heifers as compared with steers of the same age, grade, and weight. From the results of these experiments and from field tests in California, significant conclusions may be drawn:

1. Heifers, both spayed and open, fatten faster than steers and therefore reach a given slaughter grade sooner than steers. The heifers usually make smaller gains than steers; but when both classes are marketed with the same degree of finish and before they become excessively fat, economy of gain is not greatly different.

Ranch records were obtained by the Agricultural Extension Service on 1,149 yearling heifers as compared with 587 steers of the same age and quality, fed on similar rations. Each class was sold at a weight and finish suitable for California markets. The different lots of steers were fed 75 to 135 days; the heifer lots 72 to 118 days. The steers averaged a daily net gain of 1.90 pounds; the heifers, 1.81 pounds. The heifers produced their gains on 16 per cent less feed than the steers.

In six experiments cited by Morrison (6) heifer calves fattened for 165 days compared with steer calves fed for 233 days gained the same, 2.24 pounds daily. The feed required for 100 pounds gain was slightly less for the heifers.

2. If slaughtered before excessively fat (good or good to choice grades at 750 pounds or less in weight), yearling heifers yield comparably with steers and show little, if any, more waste of carcass. Under these conditions, cutting tests revealed no appreciable difference in percentage of desirable cuts. If fattened to the choice or prime grades, however, heifers are less desirable in the market, their carcasses are more wasteful, and their cost of fattening is unnecessarily increased.

3. Two-year-old heifers produce more internal fat and carcass waste than yearling heifers and calves, and compare less favorably with steers of the same age than do the younger heifers.

4. In tests at the Nebraska and California stations, spaying neither increased the rate and economy of gain nor improved dressing percentage. Any advantage from spaying comes through the guarantee that heifers are not bred, or from convenience in allowing market

heifers to graze with the general herd on the range.

5. In quality and palatability, heifer beef is equal to steer beef.

Thin cows and bulls, if healthy and not too old, will make heavy gains on good pasture or in the feed lot. They are not, however, nearly so efficient as young growing animals or mature steers in beef production, and require a wider margin between feeder and fat prices. Sometimes, especially during the fall, thin range cows and bulls can be purchased cheaply. Pacific Coast markets for slaughter cows and bulls are relatively strong and constant. Under such conditions the feeder who knows his markets, is a good judge of these classes of cattle, and has plenty of cheap feeds, can often purchase feeder cows and bulls to advantage. Rarely, if ever, does it pay, however, to use heavy amounts of high-priced feeds for fattening cows or bulls. When plenty of good pasture is available, opportunity for profit from purchasing feeder cows is increased if the cows produce calves that will fatten as veal early enough in the season to permit the cows to fatten after the veal is sold. In the purchase of cows for feeding on ranches that maintain breeding herds, the danger of introducing Bang's and other diseases should be seriously considered.

Feeder and Market Grades. The different grades of feeder cattle are illustrated in figure 16 (II). Those in grade 1, 2, and the top of grade 3 are low-set, thick-fleshed, deep- and wide-bodied animals having plenty of capacity, moderate-sized bone, short, wide heads, quiet disposition, and good weight for age. Animals of these grades can be depended upon to gain rapidly and economically, and to finish readily as calves, yearlings, or two-year-olds; they are also the first to fatten on range or other pasture. They meet a wide market demand when properly finished and are the most desirable kinds to breed and raise, because of their wide adaptability. The top of grade 2 and grade 1 animals can, with sufficient finish, attain prime slaughter grade and easily and efficiently reach the choice grade. For California markets the producer is usually justified in feeding such cattle until they are in choice to prime slaughter condition.

As a rule the finer-boned, slimmer-bodied kinds illustrated by grade 3 and 3– in figure 16 (II) gain less well. They produce trim, tidy carcasses, however, and are usually fed to good to choice slaughter grade.

Large, coarse, rough, and heavy-boned animals may also be classed in the top of grade 4 and the lower end of grade 3. Such cattle may make large gains, but are slow in maturing; when fed at an early age, they tend to grow rather than to fatten. As long yearlings and two-year-olds, such cattle often can be used to advantage in marketing large amounts of cheap roughage with moderate amounts of concentrates. The carcasses are apt to be wasteful and unattractive. It rarely pays to attempt to fatten them in excess of requirements for the good to choice grade.

Grade 4, or medium and common feeders, are plain, leggy, shallow bodied, flat ribbed, light muscled, long necked, and narrow headed. Often they have nervous dispositions, lack feed capacity, and make light gains. They are capable of economically making only commercial or good-grade slaughter cattle, depending on age at marketing.

The slaughter grades referred to above are the 1951 revised designations. See footnote table 5 (II) for brief description.

Trials at the Illinois Agricultural Experiment Station (table 30, V) show the difference in the grain (corn) required to bring to choice or to good slaughter condition various grades of feeder cattle. For practical purposes, the amount of fat required of a good-grade carcass is sufficient to make very desirable beef. The excess fattening required for the higher grades improves the quality of the lean

TABLE 30 (V)

RELATION BETWEEN FEEDER GRADE AND FEED REQUIRED TO REACH CHOICE AND GOOD SLAUGHTER CONDITION

Initial feeder grade and final slaughter condition*	Bushels corn required		Per cent of fat in carcass	
	First trial	Second trial	First trial	Second trial
Choice feeder to Choice slaughter	44.4	40.2	34.1	33.2
Choice feeder to Good slaughter	24.7	19.8	25.2	25.8
Good feeder to Good slaughter	31.5	35.1	27.4	28.7
Good feeder to Choice slaughter	....	55.8	....	34.5
Medium feeder to Good slaughter	35.7	35.2	28.8	28.0
Common feeder to Good slaughter	36.1	41.4	27.3	25.9

* Slaughter grade designations are those employed before January 1, 1951.

only to a limited extent and is wasteful, both because of the feed required and because of the fat that goes into trimmings and the garbage pail. As the data show, the corn required to put one choice feeder steer into choice slaughter condition would finish two choice feeder steers to good slaughter condition. The lower the grade of feeder, the more feed is required to reach the higher grades. Many lower-grade steers, even if sufficiently fat, will not make the higher grades because of defects in conformation.

An experienced buyer and feeder who understands the limitations of the lower grades can sometimes realize more profit from them than from the upper grades. Frequently the margin between feeder and slaughter price is wide enough, on this class of cattle, to permit profitable feeding when a greater demand for better kinds makes the margin too narrow. For the breeder and grower, however, the poorer grades always represent a poor investment.

Length of Feeding Period. If cattle are fed to a very high degree of finish, gains become much more expensive during the latter part of the feeding period. Gains at this stage consist more of fat and less of water, feed consumption per unit of animal weight is lessened, and less of the feed consumed can be used for building body tissues. Although some fat is necessary to give proper flavor, excessively fat animals are an economic loss. Less-fat animals utilize the producers' feed more efficiently; and cuts of meat that are only moderately fat cause less waste to the consumer.

Feeding Practices. Sorting of cattle, preparation and mixing of feeds, regularity of feeding, and contentment of animals, all affect the rate and economy of gains in both pasture and feed lot.

Sorting: Many feeders pay dearly for the practice of feeding and selling cattle in a "run-of-the-mill" fashion. There is much to be gained through proper sorting, especially if large numbers are involved and if the weight, quality, condition, and class vary considerably. Where practicable, the sorting of light cattle from heavy, horned from hornless, steers from heifers, and better quality from inferior, with the placing of the nervous, "high-headed"

The following tabulation indicates the approximate dressing percentages of slaughter cattle in relation to slaughter grades. The tabulation is based on grade designations effective prior to January, 1951, but should apply also to the corresponding 1951 grade designations.

Dressing percentages	63–60	60–57	57–54	54–50	50–35
Steers and heifers, grade	Choice	Good	Commercial	Utility	....
Cows, grade	....	....	Good	Commercial	Cutters and canners

kind by themselves, will bring beneficial results. Some cattle gain poorly, not because of type, breeding, or quality, but because of disease, parasites, or injury. These "poor doers" should be segregated, fed separately, and sold at the earliest opportunity. After such sorting, the feeder can better adjust the kind and amount of feed to be used, according to the appetite and efficiency of the cattle. Less trouble will be experienced with overeating, undereating, or going off feed. One great advantage in sorting comes at market time. All lots must not be disturbed every time a sale is made. Well-sorted cattle are always more attractive to the buyer. Both the upper and the lower grades look better when segregated. Only to a very limited degree can good cattle be expected to promote the sale of poor ones. Finally, if the feeder does not have his cattle sorted, the buyer will sort them for him, often to his disadvantage.

Mixing of feeds: Grinding and chopping feeds are discussed under "Nutrient Requirements and Cattle Feeds," Section III. The desire to feed concentrates and roughages mixed together is the chief reason why many feeders prefer chopped or ground hay. Other feeders choose to feed concentrates and roughages separately. Both methods have their advantages and limitations. Where the operator depends upon hired help to feed large numbers of cattle, the mixing of all feeds together is somewhat safer, with less danger that the cattle may receive too much concentrate; and labor cost also is reduced. The advocates of feeding concentrates and roughages separately declare that by so doing they can more nearly judge the appetite of the cattle for concentrates as compared with roughages and can thus better regulate percentages in a ration. Further, they can more conveniently adjust the percentages of each class of feed for different lots of cattle. The separation of concentrates and roughages also permits one to offer the two classes of feeds at different times of the day. The careful and experienced feeder with small numbers of cattle can undoubtedly feed more accurately and with greater control by giving concentrates separately from roughages.

Regularity of feeding: Concentrates must be given with great care. One serious mistake may cancel a week's gain.

Concentrates should be introduced into a ration slowly and cautiously, particularly when cattle have not been used to them. Feeder cattle that have received concentrate supplements in their stocker stage start on feed more readily and are quieter and easier to handle. If cattle are brought to a strange feed lot and are entirely unaccustomed to concentrates, it is well to feed them on roughage alone for two or three days before starting the concentrates. In separate feeding of concentrates, ½ to ¾ pound at a time may be given to calves or light yearlings for the first four or five feeds. Older and heavier cattle may be started on ¾ to 1 pound. Initial amounts can be a little greater if the cattle are used to concentrates.

All increases in concentrated feeds should be made gradually and only as the animals will clean up their feed readily without digestive disturbances. Trouble can often be avoided by making more frequent and smaller increases rather than fewer and greater increases. The amount of increase and the time required to bring the cattle to full feed must depend upon the stockman's judgment. Few lots react alike to a given ration.

If cattle go "off feed"—refuse to clean up their ration, or have such digestive disturbances as scouring or bloat—the ration should be reduced, and more dry roughage and less concentrates used for a few days. If only a few animals have difficulty, they should be segregated from the others. If many go off feed or show digestive disturbances, something is seriously wrong with the ration, the method of feeding, or both.

At no time during the feeding period should any radical changes be made, in

Fig. 34 (V). An economical type of feed-bunk construction for convenient feeding of silage, cut mixtures, wet beet pulp, or wet brewers' grains. In the right background is a mound built to reduce muddy feed-lot conditions.

either the kind or the amount of concentrates or roughages. Many lots of cattle suffer severe setbacks from such procedure. Changes in feed or too sudden increases lead to digestive disturbances and, in cattle having latent coccidiosis, may bring on acute symptoms, such as scouring, bloody mucus in the manure, and, in severe cases, fresh blood from the rectum. Segregating such animals to minimize spread of infection and feeding them exclusively on dry hay is practical.

Fattening cattle require clean, fresh feed and should not be required to eat anything once refused or dirty. Use such feed for stock cattle or other animals not being fattened for market.

When all concentrates and roughages are fed in a cut mixture, concentrates may compose a slightly greater percentage of the total feed at the start than where these two classes of feeds are given separately. With cut mixtures, however, it is always safer to employ a series of different mixtures for bringing the cattle to full feed. An alternative is to limit at first, and gradually increase the allowance of a single mix. Cattle coming directly from rich pasture go on feed rapidly; those which have been losing weight on poor feed must be handled more carefully. The schedule illustrating how rations of cut mixtures can be changed gradually in four stages is shown at the bottom of the page.

Contentment of animals: Fattening cattle that are comfortable and contented utilize their feed better and gain faster at less cost. The following suggestions are for the inexperienced cattle feeder:

1. Limit the number of cattle to be fed together to 75, preferably 50 or 60, head.

2. Provide at least 2 feet of space at the feed troughs for young cattle and about 2½ to 3 feet for mature ones.

3. Always handle cattle quietly, with as little commotion as possible.

4. In the feed lot, provide liberal bedding of straw when necessary for comfort. The straw will help to retain much of the fertilizer value of the liquid portion of the manure.

5. In the absence of sheds, windbreaks are a decided protection against cold, driving rains. Shade promotes contentment in hot weather.

6. Mud is the bane of many an operator who feeds cattle in the rainy season; it often presents a difficult problem. Mud is more detrimental when it occurs in the latter, and more expensive, part of the fattening period. It affects gains on calves and yearlings sooner than on older cattle. These points are important when one is planning the season of feeding.

	Mix 1	Mix 2	Mix 3	Mix 4
Concentrates (per cent of total mix)	20	40	50	60–70
Roughages (per cent of total mix)	80	60	50	40–30

Fattening cattle will withstand much if they can find a reasonably dry, or at least firm, spot in which to lie down. When they are forced to wade through deep mire for prolonged periods, with no good spot for rest, gains are sharply reduced and sometimes disappear. Mud-covered cattle may be discounted by the buyer, and the loss further increased.

In locating the feed lot, one should take advantage of any sandy, gravelly soil or rocky knolls. On flat ground the building of mounds in the lots (figure 34, V) helps to some extent. Often, especially with small numbers, cattle may have separate bed grounds adjoining the feeding corral. Such lots, when kept well bedded with straw, will be a welcome change to the animals for a few hours each day. On some farms, barns or sheds constructed for other purposes can be converted at little expense into feeding and bedding places during inclement weather. The cattle feeder who finds it necessary or feasible to fatten cattle each year in wet feed yards may well investigate the advisability of paving a portion of his feed lots if other means of combating the mud problem are not satisfactory.

The minimum space for fattening cattle is 100 to 125 square feet per animal. Twenty-five to 30 square feet that can be bedded under a shed in addition to 75 to 100 square feet of lot space per head is ample. An inexpensive shed bedded with straw and a paved lot may be a cheaper and more permanent solution of the mud problem than graveling larger areas or building mounds, especially on heavy, poorly drained soils. This arrangement also protects feed from rain and conserves manure.

Production and conservation of manure. Studies cited by Morrison (6) indicate that manure production from fattening cattle, including bedding, is about ¾ ton per month. In California trials, extending over a 210-day period with fattening calves, about ¼ ton of bedding was used per animal. Including this bedding, about 3 tons of manure (as hauled) or 1.6 tons of air-dry manure were produced by each steer. This amounts to 460 pounds per month. For two-year-old cattle, about 700 pounds per month would be a fair estimate. On a wet basis, these figures agree well with Morrison's data. Since more than half the nitrogen excreted is in the urine, use of bedding is particularly important in conserving this valuable fertilizer constituent. When animals are bedded under a shed, it is usually unnecessary to clean out the manure during an ordinary feeding period if there is always a liberal bedding of fresh straw. Manure leached by rain loses much of its fertilizer value. Some convenient feed-lot equipment is shown in figure 35 (V).

Necessary Margin or Spread

If feeder cattle are purchased or valued at $7 per hundredweight and must sell when fat at $9 in order for the owner to "break even" on the feeding enterprise, the difference of $2 is the necessary margin or spread. The discussion that follows shows the principal reasons for the wide variation in the margin necessary for cattle-fattening operations.

In pasture fattening of cattle the cost of producing 100 pounds gain is often less than the sale price per hundredweight of the cattle when fat and sometimes less than the value per hundredweight at the beginning of the feeding period. In feed-lot fattening of cattle, however, the cost of producing 100 pounds gain usually *exceeds* the selling price per hundredweight, and profit must be derived from enhancing the value of the feeder weight. Under very favorable price relations between cattle and feed and when good gains are made, the cost of 100 pounds gain in the feed lot may be less than the selling price of the cattle.

In computing the cost of producing gain, one must consider numerous items. The major item is the feed. Other items are labor, interest, depreciation, taxes, mortality risk, transportation, and marketing costs. Many cattle feeders consider the value of the fertilizer produced by the cattle to be equal to the labor charge. In some instances fertilizer credit may offset other minor costs in addition to labor.

When considered separately and independently, the effect of each of the principal factors on cost of gain and consequent necessary margin is as follows.

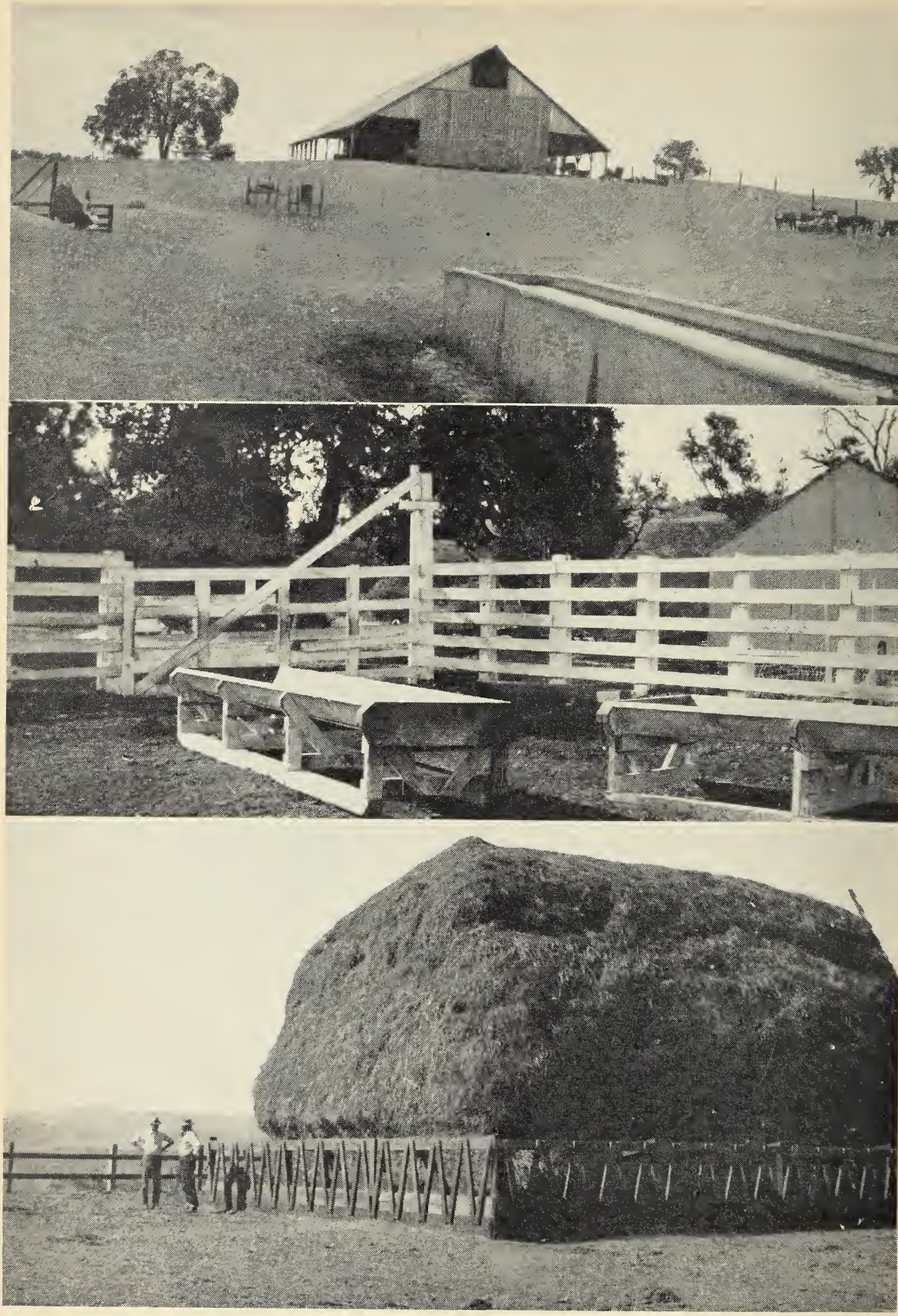

Fig. 35 (V). *Upper:* The feeding shed is located to permit good drainage. It provides feed storage space, shelter for animals in wet weather, and shade in hot weather. *Center:* The movable grain bunk is sturdy and convenient for use where concentrates and roughages are fed separately. *Lower:* The stanchion-type hay rack is built in sections and can be readily moved. This type of rack reduces waste of hay to a minimum.

1. A greater cost or value of the feeder cattle per hundredweight tends to lessen the necessary margin because the original cost more nearly approaches the cost of producing gain.

2. A greater weight of the animals as feeders tends to reduce the necessary margin because more pounds of original weight are sold at the final price. Any advantage from greater weight of older animals may, however, be more than offset by their requirement of more feed to produce gain than younger or lighter animals.

3. The production of maximum gain from each unit of feed can effectively aid in lowering the necessary margin. The stockman's judgment and skill can influence this important item more than any other.

4. A lower cost for feed per ton of digestible nutrients and a smaller overhead cost obviously tend to reduce the necessary margin.

The manner in which all these factors combine will finally decide the necessary margin in fattening cattle.

Since prices of feeder cattle and feed are the most variable among the important factors governing necessary margin, table 31 (V) was compiled to show how greatly these two factors do affect the margin. To arrive at the margins shown in the table, the following constants were arbitrarily selected:

It was assumed that a 700-pound steer was fed for 150 days, made an average net daily gain of 2 pounds, and attained a net sale weight of 1,000 pounds when fat. His average weight during the feeding period was 850 pounds, and he consumed daily 3 pounds of concentrates and dry roughage per 100 pounds of average weight. The assumed rate of gain and feed consumption are based on numerous actual records of fattening cattle under practical feed-lot conditions.

In computing costs and determining the different required margins shown in table 31 (V), the charges included cost of the steer, cost of feed, and interest on the purchase cost of the steer for 5 months at 6 per cent. Charges did *not* include such items as death loss, equipment costs, taxes, and labor; nor was any credit allowed for manure.

Table 31 (V) brings out three significant points, long recognized by experienced cattle feeders:

1. The most favorable situation in respect to necessary margin is when the feeder-cattle market is relatively high and

TABLE 31 (V)

THE EFFECT OF VARYING PRICES OF FEEDER CATTLE AND FEED ON NECESSARY MARGIN*

(All prices shown in dollars)

Cost of feed per ton	Necessary margin at a given cost of feeder cattle per hundredweight								
	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00
10.00	0.78	0.50	0.22	−0.07	−0.35	−0.63	−0.91	−1.20	−1.48
12.00	1.17	0.88	0.60	0.32	0.04	−0.25	−0.53	−0.81	−1.09
14.00	1.55	1.27	0.98	0.70	0.42	0.14	−0.15	−0.43	−0.71
16.00	1.93	1.65	1.37	1.08	0.80	0.52	0.24	−0.05	−0.33
18.00	2.31	2.03	1.75	1.47	1.18	0.90	0.62	0.34	0.05
20.00	2.70	2.41	2.13	1.85	1.57	1.28	1.00	0.72	0.44
22.00	3.08	2.80	2.51	2.23	1.95	1.67	1.38	1.10	0.82
24.00	3.46	3.18	2.90	2.61	2.33	2.05	1.77	1.48	1.20
26.00	3.84	3.56	3.28	3.00	2.71	2.43	2.15	1.87	1.58
28.00	4.23	3.94	3.66	3.36	3.10	2.81	2.53	2.25	1.97
30.00	4.61	4.33	4.04	3.76	3.48	3.20	2.91	2.63	2.35

* Necessary margins shown in the table are based on the following assumptions: A 700-pound feeder steer, fed 150 days to attain 1,000 pounds' weight after consuming feed at the rate of 3 pounds daily per 100 pounds' live weight or a total of 3,825 pounds of feed. Charges include the cost of the steer, 6 per cent interest on that cost, and the cost of the feed, but they do *not* include such items as labor, equipment costs, mortality, and taxes.

the prices of feeds are very low. If under these conditions, good feeding practices are followed, even feed-lot operations sometimes show a profit when no margin exists between the price paid for feeder cattle and their sale price when they are fat.

2. More margin is required when the price levels of both feeder cattle and feeds are low than when the feeder-cattle market is high and feed market is low. Less margin is necessary, however, when both feeder cattle and feeds are low in price than when both are high.

3. The least favorable situation of all in respect to necessary margin is to have a low feeder-cattle market and high-priced feeds. When such a price relation prevails, a margin of $4 per hundredweight, or even more, may not enable the feeding enterprise to break even.

By careful planning to bring proper adjustment between feeds to be used, cattle to be fed, and feeding practices to be employed, the stockman can often materially reduce his necessary margin and enhance his chance for greater profit. Such planning calls for a knowledge of the adaptability, requirements, and limitations of the various classes and grades of cattle. It necessitates an understanding of feeds and their values and requires good business judgment. The information and recommendations in this circular will serve as reference material for the operator who is planning a cattle-feeding program adapted to his own ranch or feed-lot conditions.

The Dressed Product

The ultimate aim of livestock producers should be the economical production and wide distribution of the kinds and qualities of meats that not only fulfill broad consumer demand and physiological needs, but also contribute to real gastronomical satisfaction.

According to studies made in this country before 1941, the annual consumption of meat per person varied from 94 pounds in families with an income of less than $500 a year to as much as 250 pounds for families with incomes of $5,000 a year. High employment and purchasing power greatly increase demand. Thus, the industry must be able to adjust production costs and methods with changing economic conditions if meat is to maintain a reasonably stable level in the average dietary.

Beef Cuts and Their Uses. Figure 36 (V) shows the location of wholesale and retail cuts to be found in the beef carcass. The identification of each cut, its approximate percentage of the carcass weight, and its principal uses are shown in the tabulation which appears on the following page.

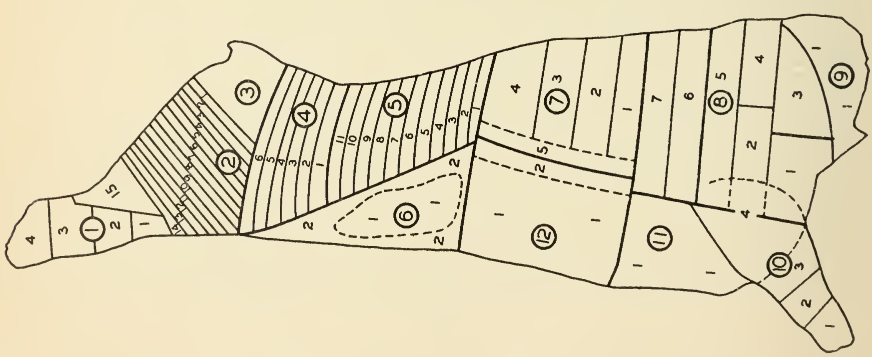

Fig. 36 (V). Wholesale and retail cuts of beef carcass. For identification of cuts see the accompanying tabulation. (Chart prepared by United States Department of Agriculture, Bureau of Agricultural Economics, Division of Livestock, Meats, and Wool.)

Wholesale cuts	Percentage of carcass	Retail cuts and principal uses
1. Hind shank	4.0	*1* to *3*, soup bones; *4*, hock.
2. Round	15.0	*1* to *14*, round steaks; *15*, heel for pot-roasting or corning.
3. Rump	5.0	Steaks or roasts.
4. Loin end	7.0	*1* to *6*, sirloin steaks.
5. Short loin	13.5	*1* to *3*, club or Delmonico steaks; *4* to *11*, Porterhouse steaks. (Kidney knob, 3 per cent, included with short loin.)
6. Flank	3.5	*1*, flank steak; *2*, stews or hamburger.
7. Rib	9.5	*1* to *4*, rib roasts; *5*, short ribs.
8. Trimmed chuck	17.0	*1* and *2*, bottom chuck pot roasts; *3* and *4*, top chuck pot roasts; *5* to *7*, chuck rib roasts and pot roasts.
9. Neck	5.0	*1*, boneless pot roasts, stews, or hamburger.
10. Fore shank	5.5	*1* to *3*, soup bones; *4*, shoulder clod (small pot roast).
11. Brisket	6.5	*1*, stews, boiling meat, or corned beef.
12. Plate	8.5	*1*, stews, boiling meat, corned beef; *2*, short ribs.

Value of Meat in the Diet. The factors that influence the quality of dressed beef are important to producers in planning their production programs.

Meat is the nucleus of well-balanced meals. Its value and place in the human diet may be summarized as follows:

1. Meats are rich in proteins having high biological and supplementary value for cereal and other vegetable proteins. The average serving provides more protein than any other article in the diet.

2. The average serving of meat ranks high among other foods as a source of energy.

3. Meats head the list of foods in amount of phosphorus, iron, and copper, but are low in calcium. Liver contains substances other than copper and iron that are valuable for relieving anemia.

4. Lean meat contains liberal amounts of the vitamin-B complex. Fresh lean meat contains enough vitamin C to prevent scurvy. Liver is a rich source of vitamin A and supplies all known vitamins.

5. Meat is 95 to 98 per cent digestible. It contains nitrogenous extractives that stimulate appetite and digestion, contribute to the flavor of meat, and hence increase the pleasure of eating.

Beef is more variable than pork or lamb because of the greater difference in age and condition of the animals. There is also more difference in tenderness of various parts of the beef carcass. Demands of different classes of consumers vary. In buying beef the consumer considers proportion of meat to bone, relation of lean to fat, distribution of fat and lean, color and texture of fat, lean, and bone. To the average consumer *tenderness* is the first consideration in satisfaction of eating, and normal variations in *flavor* rank second. If flavor happens to be disagreeable through spoilage or other causes, flavor then is paramount. Breeding, feeding, age, sex, methods of slaughtering, curing and ripening, and manner of cooking all influence the desirability of the product.

Tenderness. The degree of tenderness of beef depends on the amount of connective tissue. Tenderness decreases with age and presumably with exercise. In calves the muscle-fiber bundles are small, giving fine texture, whereas in mature animals they are larger and the surrounding connective tissue becomes thicker, producing coarser "grain." Deposition of fat in and between these connective tissues disperses them and increases tenderness.

Continuous growth and development contribute to tenderness. The animal so grown not only is younger when marketed but perhaps develops less connective tissue than cattle which are subjected to alternate gains and losses. Quin (7) in South Africa reported that as animals become thin and emaciated through semi-

starvation during drought periods, the fat, including that interspersed through the muscles (marbling), disappears. Next, the animal is forced to start feeding on its own flesh to protect and nourish the more vital systems. As this muscle atrophy or wastage progresses, the amount of connective tissue increases through the remaining muscle and thereby causes toughness. During subsequent periods of feed abundance the animal may fatten, but largely outside the muscle; the internal structure of the muscle shows a network of fibrotic scar tissue of the previous dry or winter season. It then appears marbled with connective tissue instead of fat. This condition reduces palatability, digestibility, and therefore food value. In Quin's opinion, prevention of these periods of excessive weight losses and muscle wastage would help solve the tough-meat problem.

To attain the same degree of tenderness, older animals must be fattened more than younger ones. There are two types of connective tissue—yellow and white. When cooked with moist heat, white connective tissue changes to gelatin, and thus increases in tenderness. Supporting muscles, such as the back and loin, are more tender than the muscles of locomotion. The retailer separates the cuts on this general basis. The more tender cuts are used for steaks, chops, and roasts that are cooked with dry heat. The less tender cuts are made tender by moist heat, such as boiling or pot-roasting. Enzyme action that occurs in the tissues while aging in the cooler increases tenderness and improves flavor. The extent to which beef can be aged depends largely on the degree of fatness; fat protects the surface of the carcass from molds and from bacterial action.

In studies at the Kansas Station, beef produced on phosphorus-deficient pasture or feed-lot rations proved inferior in keeping quality, shrinkage, and palatability. The low-phosphorus rations caused changes in relative amounts of phosphorus, calcium, and nitrogen, especially in the fat. The tissues became more permeable. More juice could be pressed out. These conditions of increased permeability and higher moisture losses were associated with earlier spoilage and hence limited the aging period.

Flavor. Beef flavor is affected by age, sex, finish, aging or curing, cooking, and seasoning. Intensity of flavor increases with age from veal to mature beef. Flavor is affected by fat, particularly that interspersed with the lean (marbling). The flavor of the lean is due in large measure to the meat extractives (the water-soluble materials that are found in broth). Feeds usually play only a very minor role in beef flavor except as they govern degree of fatness. Juiciness is important in flavor. Well-finished beef will remain juicy and hence better flavored than poorly finished beef.

The amount of "watering off" both in cooking and in the butcher's tray depends not only on finish, but also on the amount of glycogen in the muscles at time of slaughter. During the changes in the muscle ending in *rigor mortis*, glycogen is converted to lactic acid, lowering the pH. Low glycogen content caused by fatigue and lack of feed before slaughter results in higher pH (less acid), a more closed structure of the meat, and less tendency to "weep." This, within limits, may be desirable for the tender cuts, but is unfavorable toward tenderizing during aging. Moreover, higher acidity inhibits bacteria and molds and increases resistance to spoilage.

Color of the Lean. The color of lean beef is due primarily to muscle hemoglobin (iron-containing red coloring matter), but the brightness is modified by the amount and distribution of fat in the lean. Muscle hemoglobin increases with age and presumably with exercise. Whereas veal is very light, the meat from bulls and from aged cows is dark. The amount of muscle hemoglobin bears no relation to the hemoglobin in the blood.

Although exercise perhaps affects the color of the lean, it apparently is a minor factor under practical conditions. At the Illinois Agricultural Experiment Station, exercise equivalent to traveling more than 7 miles daily during fattening failed to change the color of lean beef materially. Although grass-fed cattle are commonly thought to kill darker than feed-lot cattle, experiments at the Virginia Station revealed no difference when grass-fed and feed-lot cattle had equal finish. Similarly no practical difference was found by the Kansas Station, although delicate analyses revealed slightly more muscle hemoglobin in pasture-fed cattle.

The freshly cut surface of beef is dark, similar to venous blood. Upon exposure to air it brightens to resemble arterial blood. This brightening is rapid for 30 minutes and continues for as much as 3 hours. After this time it may darken again permanently, owing to decomposition of the hemoglobin.

In some carcasses the cut surface of the "eye of beef" or other muscles fails to brighten and may be almost black. This condition is known in the trade as "dark" or "black cutters." It may occur even in young, well-bred, and well-finished animals. It is commonly said to be caused by overheating, excitement, and exercise before slaughtering, or by improper bleeding. The condition is not predictable before slaughter. Because of its appearance, sales are induced by sacrifice in grade and price. Chicago packers have estimated their combined yearly loss at one million dollars. Considerable investigational work has been done on the problem by experiment stations and by a committee of the National Livestock and Meat Board. The findings are reviewed in Kansas Agricultural Experiment Station Technical Bulletin 58 (8).

The conclusion has been reached that dark-cutting beef is caused by deficiency of glycogen (animal starch) in the tissue at the time of slaughter. The dark beef is low in lactic acid and sugar (glucose), contains practically no glycogen, and has a high rate of oxygen uptake, which keeps the muscle hemoglobin reduced to the dark venous form. The environmental or individual variations responsible are still imperfectly understood. The condition may be produced by insulin injections that deplete carbohydrate reserves and cause shock. It appears to be promoted by starvation for 3 days, such as frequently occurs in shipment, particularly if followed by extreme fatigue, induced by sudden exposure to low temperature and shivering. It appears to be more common in nervous animals and in those having little exercise during fattening. Such animals may be more subject to shock under starvation and drastic environmental changes. Although the trouble occurs in California, it appears to be less important there than on the midwestern markets.

Color of the Fat. Yellow color of beef fat is caused by deposition of carotene, the precursor of vitamin A. Carotene cannot be formed in the animal body; it must be obtained from plant sources. It is present in all green plant tissue and in yellow roots.

The amount of carotene in the fat of cattle depends on: (*a*) the carotene content of the feed, (*b*) hereditary variation that limits its storage, and (*c*) storage as affected by the age of the animal. Green pasture is rich in carotene and hence tends to produce the most color in beef fat. Even the best-cured hays have lost a high percentage of this constituent; thus they have less tendency to produce yellow fat. Grains, oil meals, and other concentrates are all low in carotene.

The meat trade frequently associates yellow color with "cake"-fed cattle. Cottonseed cake contains no carotene, however, and a ration of cottonseed cake and hulls produces white fat. Cake-fed cattle often are "warmed up" on grass or fed for a short time on dry forage, and they commonly retain the yellow color accumulated during the green-feed season.

The calf at birth contains no carotene, regardless of the mother's feed. Storage increases with age, so that under the same feed conditions yearlings have less fat color than two-year-olds, and they in turn less than mature cattle. On the same feeds, Jersey and Guernsey cattle store more carotene in their fat tissues and secrete more in their milk than Holstein or beef breeds. The latter change more of the carotene to colorless vitamin A. Individual variations with respect to fat color occur within breeds.

Old cows and grass-fed cattle which often are not well finished are most likely to have yellow fat. Hence, this color was thought to indicate poor quality, and there has been prejudice against it, although it is the same color that is highly prized in cream and butter. The carcasses of young well-finished cattle may be yellow if the animals have had feeds high in carotene. On the other hand, dairy cattle fed exclusively on feeds lacking in carotene have white fat. Color is therefore not a reliable index of quality. Yellow fat, though often coincidental with lower grades, is not necessarily associated with soft fat or any other condition affecting desirability. In view of these facts, color should be minimized in beef grading.

Discrimination against yellowness may be unfortunate for both consumers and producers. Often the latter can economically produce high-quality beef in other respects by utilizing pasture and forages that are cured to retain highest nutritive value. Although the prejudice has been difficult to overcome, it is now gradually disappearing.

Fattening. Fattening occurs in three overlapping phases: first, around the kidneys and internal organs; second, over the surface of the muscles; third, in the lean tissues. Cattle poorly bred for beef cannot readily or economically be brought to the final stage. They tend to become wasteful in internal and external fat without distributing it evenly over the body and through the lean. The tendency for marbling and fine texture of lean is hereditary. Fattening increases yield, tenderness, flavor, and to a slight extent the proportion of hindquarter to forequarter. Adequate finish protects the carcass in the cooler and permits aging. It increases juiciness and decreases moisture loss in cooking. Excessive fat does not improve flavor; it is uneconomical to produce and largely goes into garbage.

Some of the results of coöperative investigations between experiment stations and the National Livestock and Meat Board on quality and palatability of beef are summarized as follows:

No important differences were found in quality or palatability of meat from different beef breeds. The chief differences between meat from cattle of improved and unimproved breeding, fed similarly, were found to be in weight for age, in yield, and in appearance of the carcasses. Heifer and steer beef were found equal in palatability.

Various practical balanced rations comparing, for example, corn with wheat, cottonseed meal with linseed meal, and hay with silage, have not, in general, much affected the palatability of the resultant meat. Beef from three-year-old steers fed 8 pounds of grain daily on good pasture was fatter and more attractive but only slightly more palatable than the beef from steers fed on good pasture alone. Apparently the color, tenderness, and desirability of lean depend more upon other factors than upon the amount and character of the grass or grasses that the animal has eaten.

Heifer beef proved definitely more tender than beef from cows five years old or over, although there were no marked differences between them in flavor or juiciness. On the other hand, roasts from fattened two-year-old and yearling steers, though more palatable in general than roasts from fattened calves, showed no significant differences in tenderness. Distribution of fat through the lean was more satisfactory in beef from yearling and

two-year-old cattle than in beef from calves finished as short yearlings. Age of the animal had little influence on the percentage of the various cuts of beef among fattened calves, yearlings, and two-year-olds.

Richness of juice appeared to improve somewhat with increasing finish, although a highly desirable richness of juice does not require excessive finish.

Creep-feeding previous to weaning increased the fatness, dressing percentage, storage quality, and attractiveness of the resultant beef.

Steers that had lost weight on drought-stricken pasture produced meat containing a most undesirable flavor and odor according to the results secured in one trial.

Producers can control or influence the quality and desirability of the beef by the following methods:

1. Breeding and selecting for thick-muscled, early-maturing cattle, which fatten readily and distribute the fat evenly.
2. Feeding to promote continuous growth.
3. Fattening at an early age or to a degree adequate for particular classes, grades, and ages of cattle.
4. Dehorning at the proper time and careful handling of cattle to prevent injuries and bruises in shipment to market.

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